SAE journal

MARCH 1959

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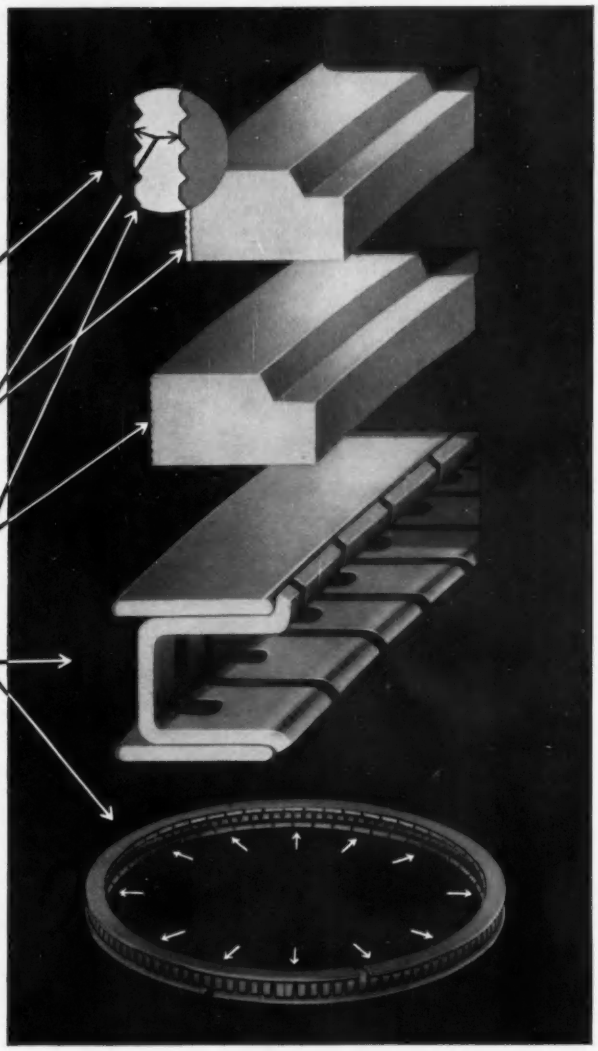

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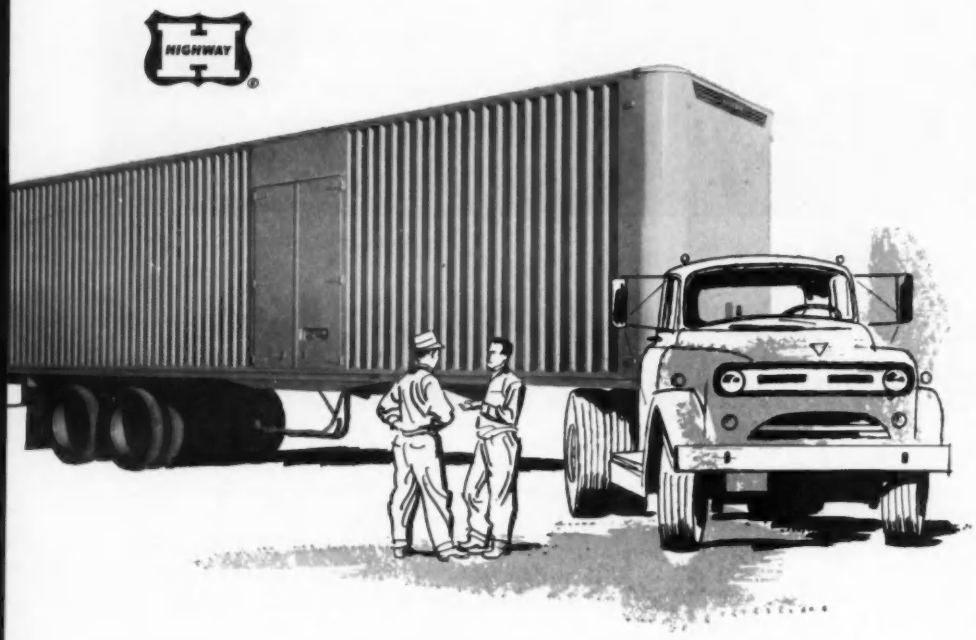

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AIRCRAFT

Precise Electric Power for Ground Support of Missiles, D. GINSBERG. Paper No. 7R. Features of equipment developed by Army Corps of Engrs. which encompass d-c, 60- and 400-cycle generator sets in ratings from 0.150 to 150 kw; characteristics of sets; design approach used to obtain desired voltage waveform, transient response and light weight; application of magnetic amplifier; transistor and load compensated static exciter; electric load sensing governor, instruments and circuits; electromechanical properties of system.

Aerophysics Aerial Platform VZ-7AP, R. W. EVANS. Paper No. 10T. 4-rotor Aerial Platform, developed jointly by US Army and Curtiss-Wright Corp, features low, flat cargo deck suitable for variety of payloads, vertical takeoff and landing, hovering, and ample forward speed; use of guards around rotors and small size, to allow vehicle to be transported by truck, ship or cargo aircraft; background, preliminary design, and physical description; propeller ground tests; control system.

Self-Contained Turbomachine Systems for Aircraft and Vehicular Air Conditioning, H. K. ZIEBARTH. Paper No. S116. Turbomachine applications as key components of aircraft air conditioning and refrigeration systems; system for missile ground support van; applications in land and sea transportation, such as atomic submarine, tuna seiner, destroyers and small passenger liners, dome railroad coach, and transcontinental bus; features which make gas turbine highly suitable energy source for air conditioning and refrigeration systems.

Engine Bleed Ducts, Production Engineering and Qualification Testing, W. J. Van den AKKER. Paper No. S130. Design requirements, selection of materials, and specifications with respect to metal thicknesses; types of stainless steel used; joining of sections by methods of welding employed at Stainless Steel Products; life or destruction type tests.

Progress Report. . . . Convair 880 and Convair 600 Turbojet Transport, H. DUCKWORTH. Paper No. S137. Outline of two aircrafts, each designed to meet different performance characteristics; Convair 880 is scheduled for initial flight tests Jan. 1959; preliminary flight tests and CAA certification expected May 1959; Convair 600, with speeds beyond Mach 0.90, will have takeoff weight of 238,200 lb in normal flight and 4400 mi range; initial deliveries scheduled for June 1961.

Lockheed Electra — Progress Report, C. F. SCHMIDT. Paper No. S138. Background of prop-jet project, designed to meet following requirements; high degree of passenger appeal, low operating cost, ease of maintenance, and operational flexibility and reliability; outstanding features and developmental history; functional and flight tests, involving four aircrafts.

Theory and Instrumentation of Inertial Navigation Systems, J. STATSINGER. Paper No. S119. Basic concepts of system represented in mathematical terms; requirements for mounting and orienting accelerometers; how proper velocity and displacement component may be obtained

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from accelerometer outputs shown by reference coordinate system which has fixed orientation in space; computer applications.

Radiation Shielding Aspects of Nuclear Aircraft, N. M. SCHAEFFER, R. L. FRENCH. Paper No. 2R. In-flight experiments and associated ground level experiments are comprised in Airborne Shielding Program undertaken at Convair, Fort Worth; shielding problem is primarily one of studying each of major processes contributing to crew dose rate; Aircraft Shield Test Reactor is 1000-kw reactor, cooled, moderated, and reflected by water; experiments included ground level, flight, and tower experiments; sample results.

Lockheed's Georgia Nuclear Laboratory, W. R. RHOADS. Paper No. 2S. Mission of Air Force Plant No. 67 laboratory is to support Aircraft Nuclear Propulsion Program planned by Air Force and Lockheed; problems of designing aircraft operating at practically constant weight throughout mission and coping with new environmental parameter which is measure of amount and type of radiation escaping from reactor used, features of research Radiation Effects Reactor (RER); plan of Nuclear Support Laboratory and other support facilities.

Design and Development Problems of Radiation and High-Temperature Tolerant Electronic Equipment, J. G. STUART. Paper No. 2T. Study by Aircraft Nuclear Propulsion Dept. of General Electric Co., to develop components for certain electronic equipment; interactions that cause damage are ionization, displacement, and transmutation; evaluation of materials for radiation tolerance and resistance to high temperatures; design and development of 3-stage preamplifier circuit; operating characteristics; additional development work.

Materials Problems Encountered in Liquid Propellant Rocket Engines, D. E. RODA. Paper No. 4R. Features, testing and use of typical large liquid propellant rocket engines, materials problems in production processing and fabrication of 410 and 440 C stainless steel valve shafts, SAE 9310 steel gears, and Tens-50 aluminum castings, etc.; problem areas with respect to thermal expansion; low temperature mechanical properties, and fatigue; compatibility, recent material requirement, can be solved through proper selection, plating and protective coatings.

Thermal Insulation Ceramic Coatings, A. V. LEVY. Paper No. 4T. Advanced aircraft and missiles require ceramic coatings to protect metal components in combustion area of engines (gas turbine, etc) that overcome shortcomings of frit type coatings; present state of flame spray unreinforced coatings; method of preparing surface of metal; reinforced ceramic coatings; types and configurations of reinforcing media under investigation; properties of two typical reinforced coatings.

Missile Ground Equipment, B. J. MELDRUM. Paper No. 5T. Ground equipment used for transporting various components in connection with launching of Redstone ballistic missile developed for tactical use by Department of Army; features of transport for thrust unit or "booster," towed by standard Army tractor; aft unit container, housing guidance and control system in special heated container; erector truck, and liquid oxygen trailers; equipment used in support area.

Choosing Rubberlike Materials for Use with Synthetic Hydraulic Fluids, E. A. WEBSTER, R. G. LARKIN. Paper No. 9T. Factors in selection of basic gum or family of polymers for seals and gaskets, flexible hose liners, line clamp cushions and accumulator diaphragms in aircraft applications; methods of predicting material compatibility with particular fluid are "similarity rule" and "solubility parameter concept"; attributes of three typical O-ring materials with regard to hardness, ultimate tensile strength, and compression set; performance requirements.

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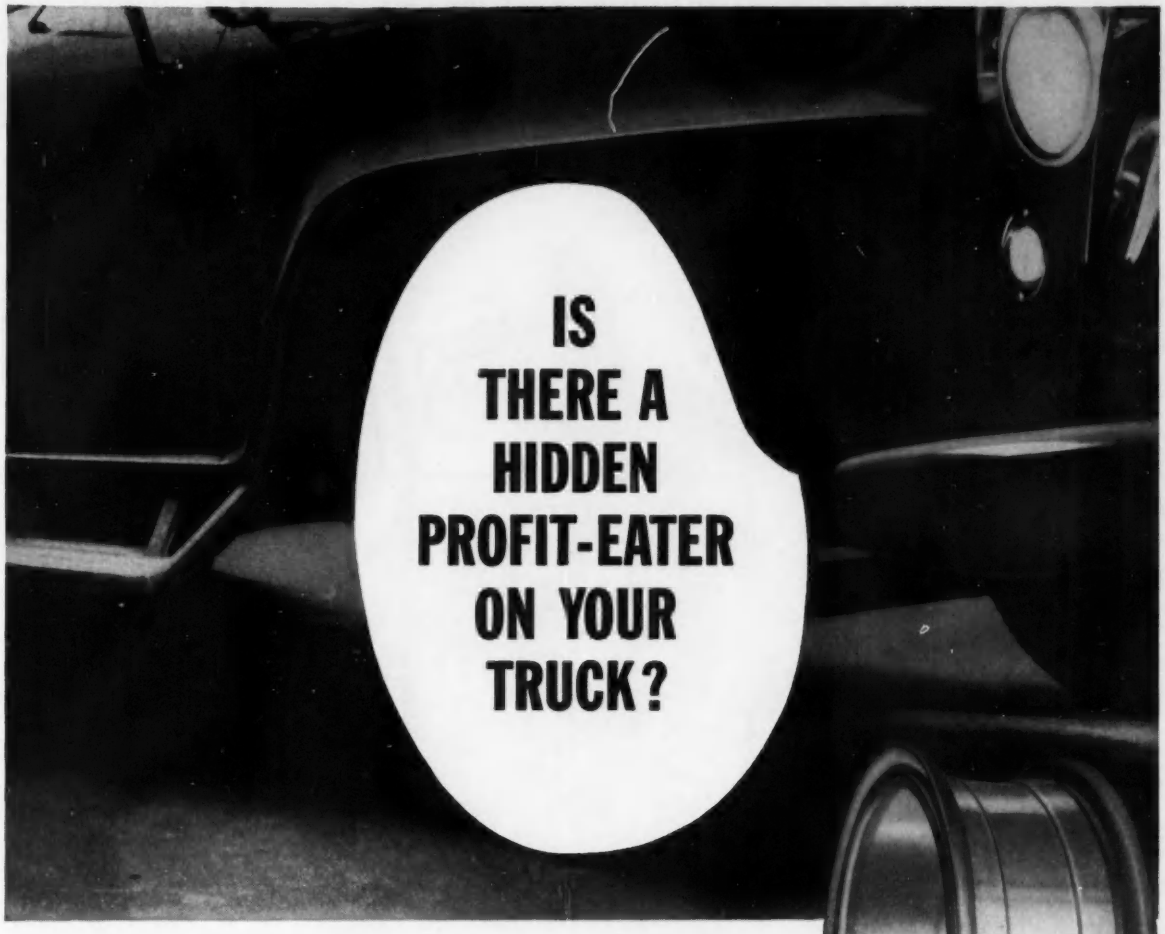

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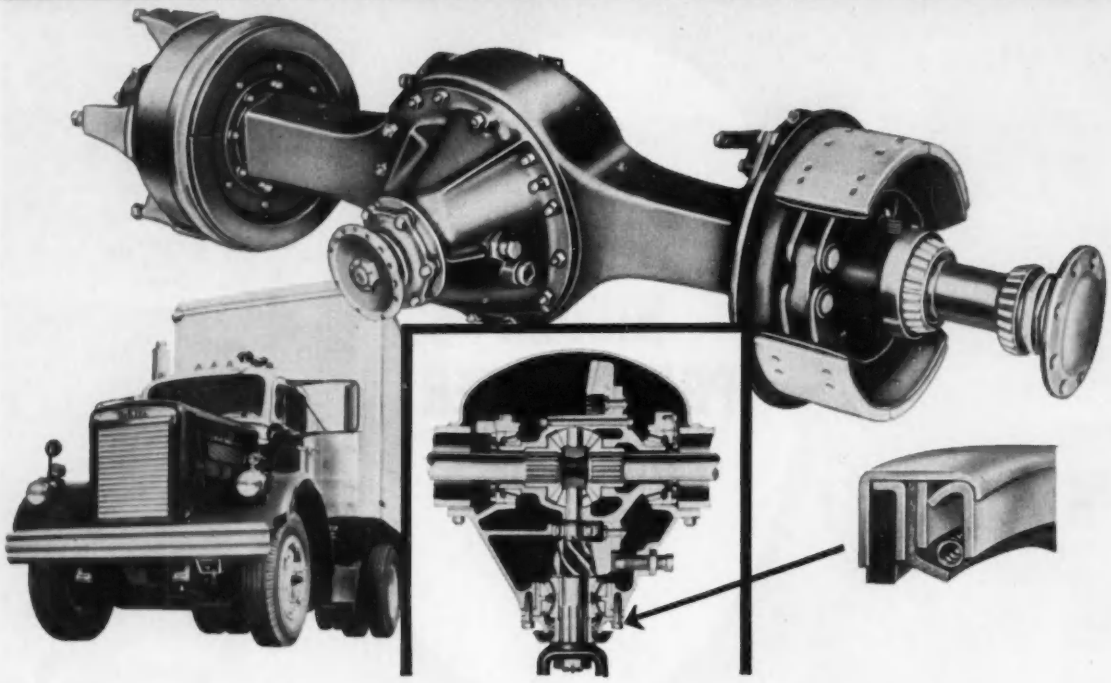

How White Trucks employ dual-lip National seal to protect axle pinion assembly

The use by the White Motor Company of a National 15,000 series oil seal in their 189C Single Reduction Rear Axle is a skillful employment of a standard-design seal to attain dependable and economical sealing.

Conditions at the sealing point are: S.A.E. 90 gear oil to be retained, dirt and water to be excluded, temperatures —20° to 180° F with normal operation at 150° F, maximum shaft speed 3,500 rpm, eccentricity and runout .002, shaft diameter 2¾", 15 RMS finish. Operation is of course intermittent with servicing conditions generally good.

Rather than two seals to respectively retain lubricant and exclude foreign matter, White engineers specified National 15004, a dual-lip Micro-Torc leather and felt seal wherein the leather sealing lip is spring-tensioned and faces inward to retain gear oil and the other felt lip is a wiper excluding dirt and dust.

National 15004 is but one of 2,500 different standard design seals National provides. For complete information on leather, synthetic rubber or other seals, call your National Applications Engineer. Look under Oil Seals, in the Yellow Pages.

NATIONAL SEAL

Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California;
Plants: Van Wert, Ohio, Downey and Redwood City, California

Before specifying seals, consider all these points!

Shaft RPM, Runout, Endplay
Is seal rated at or above anticipated operating extremes?

Temperature, Lubricant Types
Will heat or special-purpose lubricants attack sealing lip material?

Presence of Dirt, Foreign Matter
Point often overlooked. Should dual-lip or double seal be used?

Cost Related to Seal Design
Will a simpler, cheaper seal do as good a job as a more sophisticated design?

New Seals and Material Available
Are there new materials or compounds which can do the job better?

Special Design Oil Seals
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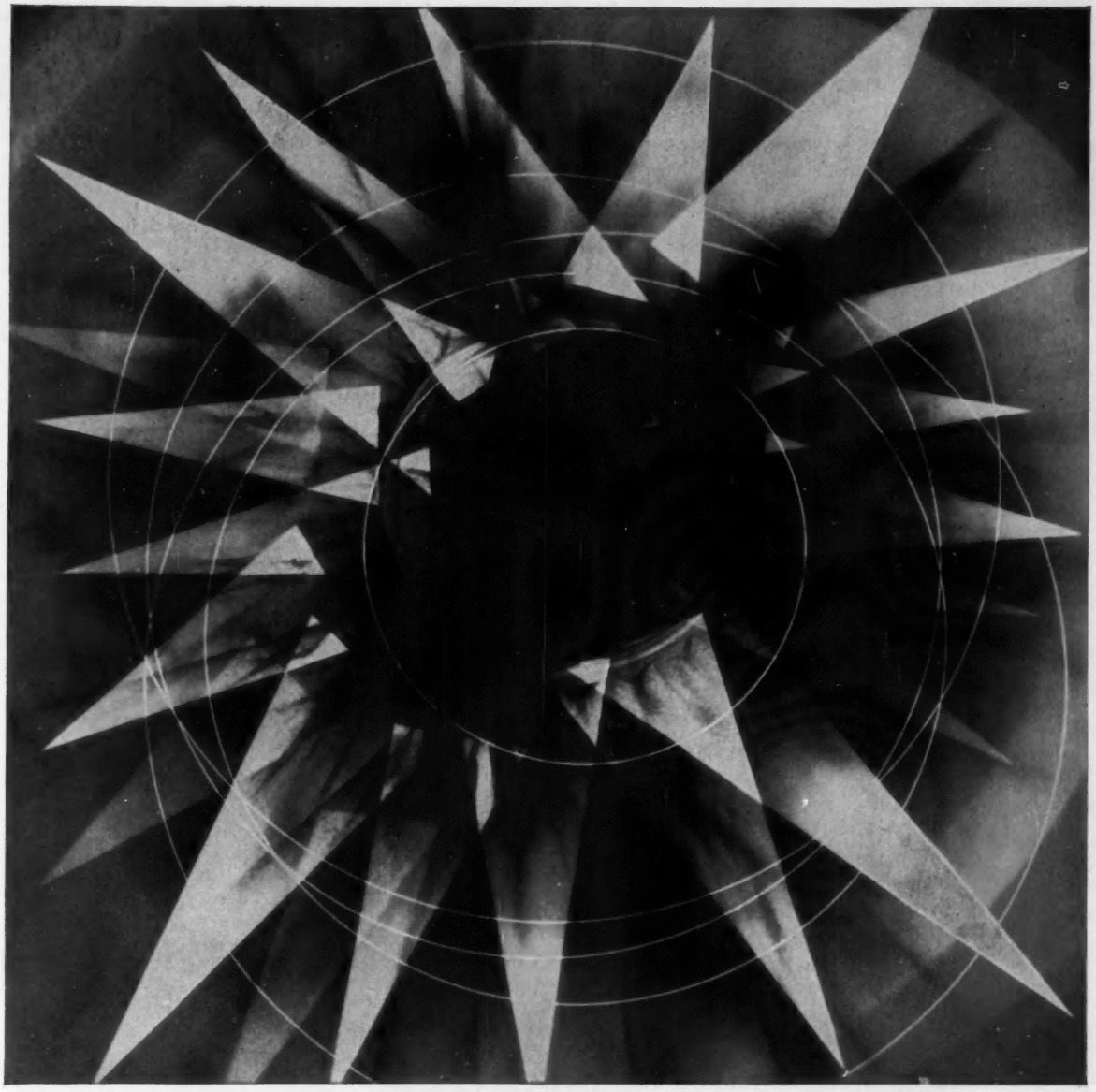

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Today's challenge lies in developing metals and means of cracking the thermal barrier.

The metals problem has already been partially solved by superalloys produced through Vacuum Induction Melting. This process, as developed by Kelsey-Hayes, has yielded such super refractory alloys as Udimet 500, 600 and 700—clean, pure alloys combining unsurpassed stress-rupture life with superior high tensile strength above the 1500°F range.

In addition to making new superalloys, Kelsey-Hayes upgrades existing alloys through vacuum induction melting.
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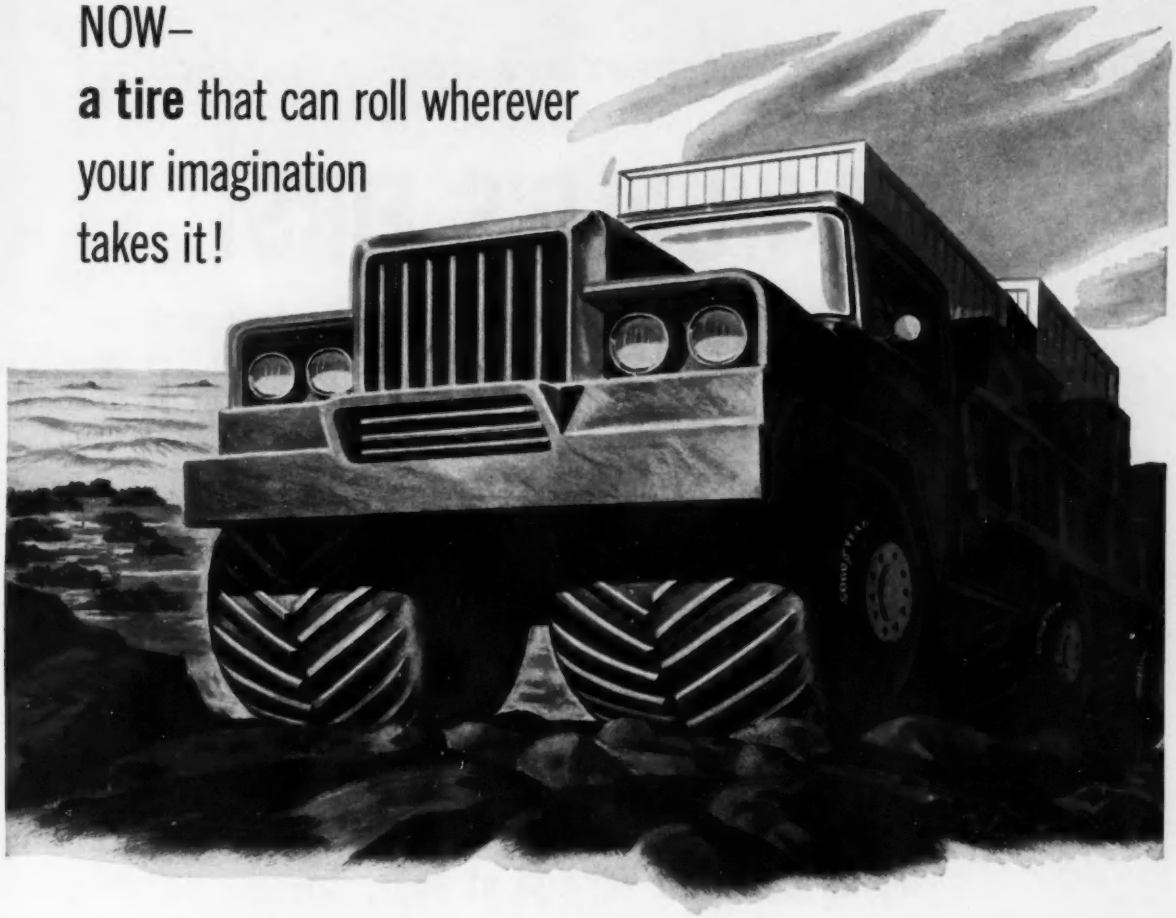
a tire that can roll wherever your imagination takes it!



This is the Terra-Tire—developed by Goodyear to give military vehicles unprecedented mobility. It is now ready for commercial applications wherever a tire is needed to traverse *any* terrain without miring down or digging in. Axle-driven and axle-loaded, these air-filled "pillows" *conform* to the ground contour—give with sharp objects rather than resisting them, are virtually immune to punctures and blowouts. And since Terra-Tires carry only 3 to 10 pounds' pressure—the ride is so cushion-soft springs aren't needed!

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WHERE CAN **TERRA-TIRES** SAVE FOR YOU? DESIGNERS: by designing vehicles from the start to utilize the unique engineering advantages of Terra-Tire transportation, substantial savings in space and weight can be realized. For more information, contact Goodyear, Aviation Products Division, Akron 16, Ohio.

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THE WORLD'S FIRST TRANSISTORIZED IGNITION!

The ignition system of the future... achieves lifetime contact service, unequalled reliability, higher constant voltage at every speed

Auto-Lite is proud to announce the world's first transistorized high voltage ignition power supply. This completely self-contained system represents a major break-through in ignition engineering . . . it marks the first practical use of transistors in the automotive field. And it shatters voltage limitations imposed by conventional systems for fifty years . . . supplies voltages throughout the speed range unobtainable until now.

The transistorized system is so new, so different, that it cannot be compared with any system now in use. It is a completely new concept in ignition engineering. When the coil of a present system is replaced with this Auto-Lite development, you obtain these advantages:

1. No more contact bluing . . . no more point replacement due to electrical erosion.

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3. More available voltage . . . output is equivalent to a battery ignition system at low speeds, a magneto system at high speeds.

This revolutionary advance in ignition engineering makes available the higher ignition voltages required by higher compression ratios. And this new Auto-Lite development has immediate applications in the industrial, marine, agricultural, fleet, military, and automotive fields . . . and wherever else system longevity and superior performance are demanded.

For information write to: THE ELECTRIC AUTO-LITE COMPANY, TOLEDO 1, OHIO

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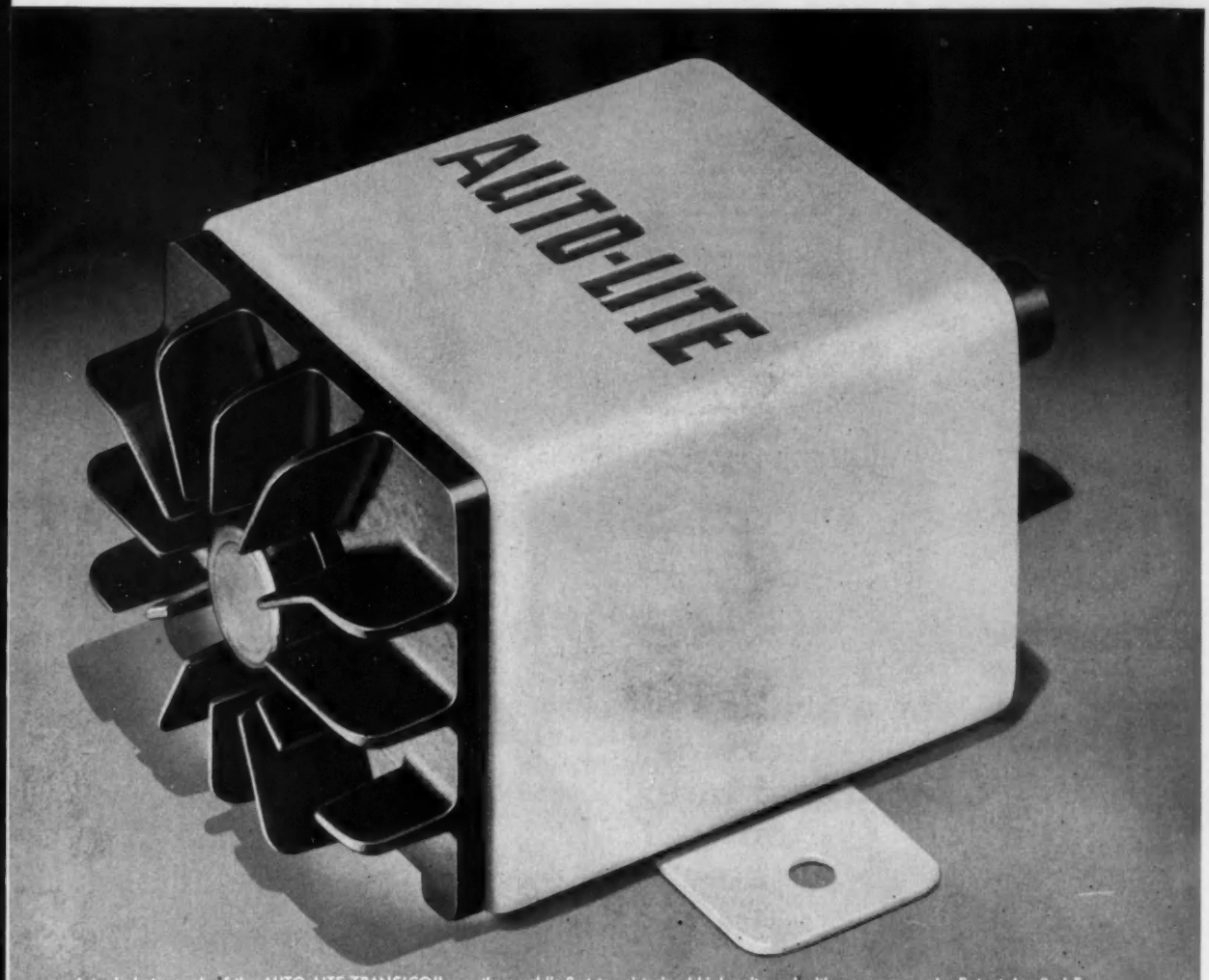
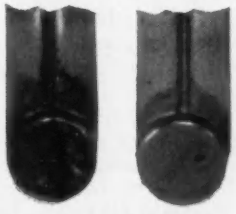


Actual photograph of the AUTO-LITE TRANSICOIL . . . the world's first transistorized high voltage ignition power supply. Patent Applied For.

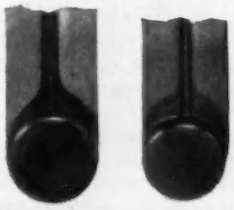
SOLVED: Three major ignition problems

CONTACT EROSION



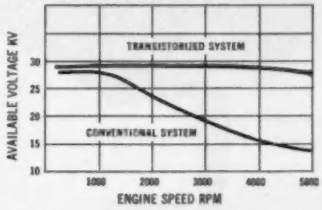
1500 hours under identical conditions. Each of these points was run 1500 hours, the equivalent of 44,000 miles. The contact used with the conventional system is deeply eroded and approaching the end of its useful life. The contact used with the transistorized system is only slightly discolored.

BLUE POINTS



Eliminates starting and performance problems caused by blue points. Each of these contacts was run through identical conditions of repeated starting at –20°F. The transistorized system shows no evidence of contact oxidation.

VOLTAGE FALL-OFF



Greater available voltage is clearly shown on this typical performance curve. At higher engine speeds present systems lose voltage, cut down ignition power. The transistorized system, however, maintains a nearly constant voltage supply throughout the entire speed range.

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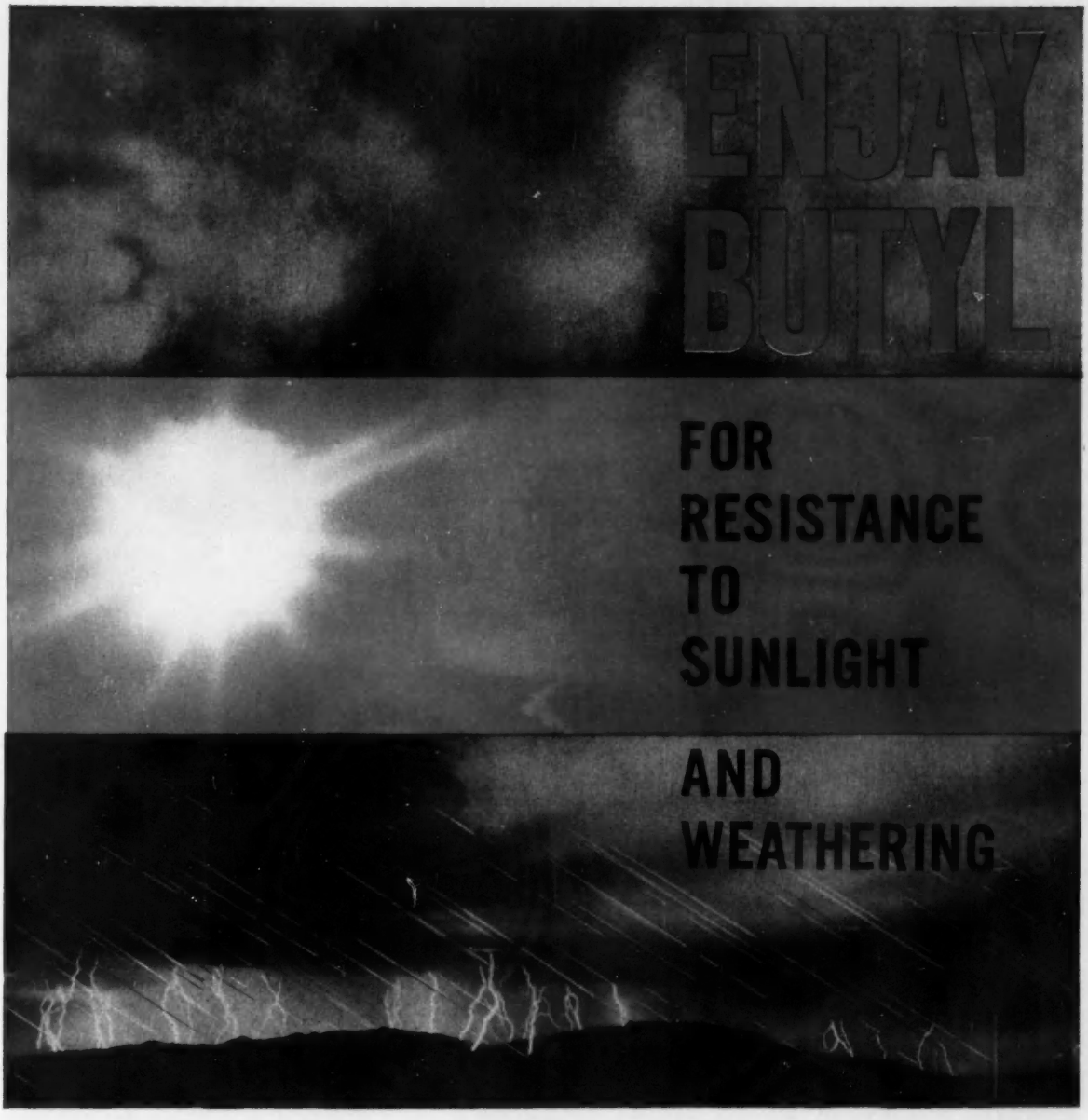

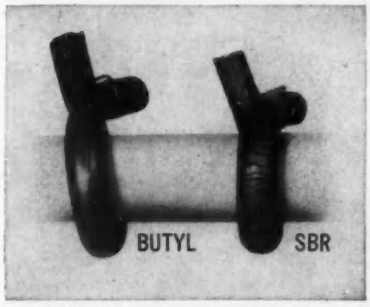

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Butyl *also* offers...outstanding resistance to chemicals, abrasion, tear and flexing . . . superior damping qualities . . . unmatched electrical properties and impermeability to gases and moisture.

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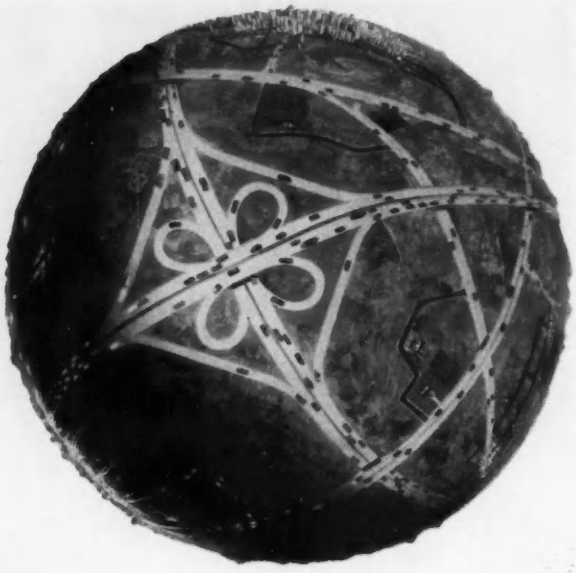

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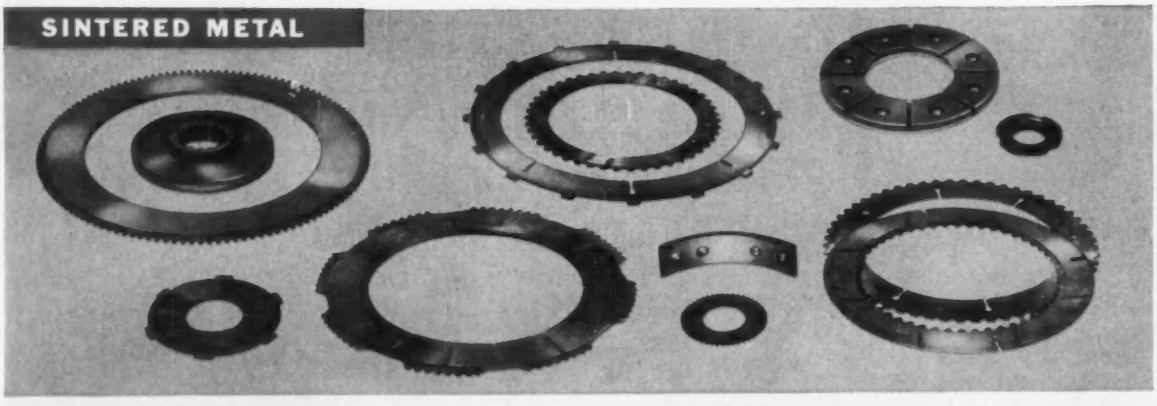
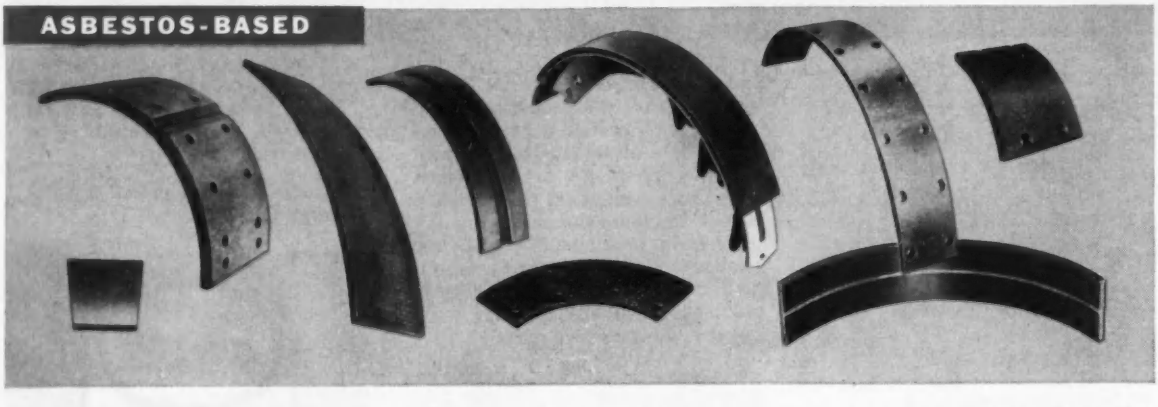
...for a world of stop and go





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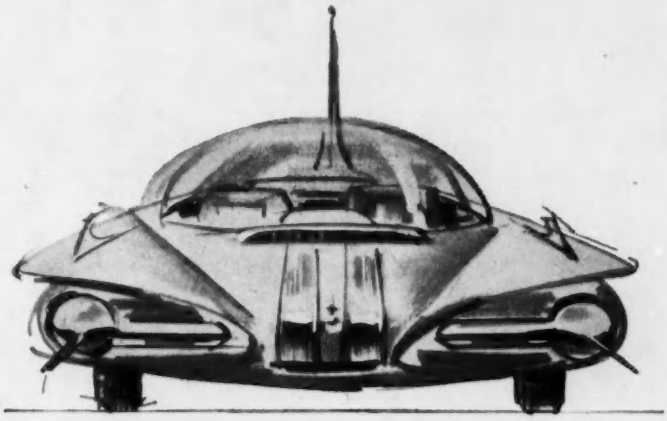

PUROLATOR'S DRY TYPE AIR FILTERS GIVE

COMPLETE DESIGN FREEDOM

With Purolator's new dry type air filters, there's no need to keep a constant, level bearing . . . to set the air cleaner on top of the block. There is no oil to spill, no level to be maintained. This makes it possible to place the filter anywhere at all . . . under the engine, on the side . . . wherever it allows the most design freedom.

Of course, the big advantage in dry type filtration is the optimum efficiency it affords. The Micronic dry type element is just as effective at low speeds as at high speeds. And instead of becoming less efficient with use, its already outstanding 99% efficiency *increases* to 99.7%.

Design your cars the way you want them . . . then call on Purolator to design and produce the air filter to fit your design.

Filtration For Every Known Fluid **PUROLATOR**

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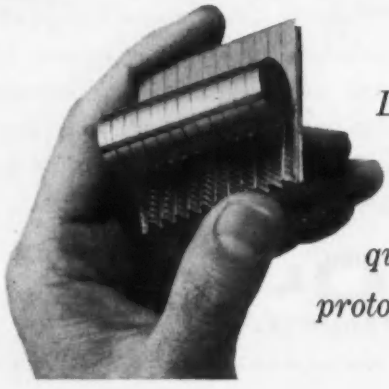
After 8 years of research North American introduces a low-cost Space Age material:

SPACE

A WELDED STEEL SANDWICH



Designers may now obtain experimental quantities for prototype development

WHAT IT IS: SPACEMETAL is a stainless-steel sandwich with the light weight, high strength, and heat resistance required for Space Age missiles and planes. Inner sheet is beaded to form a V-shaped corrugation which allows rapid heat dissipation, permits hydrostatic testing for quality control. Yields weight savings (theoretical) as high as 75 percent over solid materials.

Manufactured by

METAL

THAT'S BEING MACHINE-PRODUCED

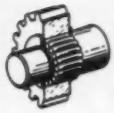
HOW IT'S MADE: Production line machinery, developed by the Missile Division of North American Aviation, manufactures SPACEMETAL at the rate of 50 square feet per minute. The sandwich is now produced in 30-inch-wide panels, from type-301 stainless steel with a nominal gauge of 0.156 inches. Resistance welding eliminates excess weight of brazing or adhesive materials.

WHY IT'S STRONGER: SPACEMETAL's V-configuration core offers greater strength in one direction than usual honeycomb structure. SPACEMETAL is 235 times stiffer and can carry 23 times the bending load of solid type-301 stainless steel of equal weight. Beads along the sides of the corrugation double its crushing strength and improve other physical properties.

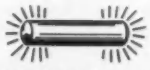
HOW TO GET IT: SPACEMETAL is available in experimental quantities to designers seeking its unique properties for application in missiles, supersonic aircraft, and related projects. Please write for complete information, outlining your requirements, to: SPACEMETAL, Dept. 496 F, Missile Division, North American Aviation, Inc., 12215 Lakewood Blvd., Downey, Calif.

THE MISSILE DIVISION OF NORTH AMERICAN AVIATION, INC.

Full complement of small diameter rollers insures maximum number of contact lines in load zone for high radial capacity in minimum space.



Mounted without races between hardened shaft and hardened housing (RC-60 recommended), Torrington Needle Rollers allow largest possible shaft diameters.



Carefully hardened, ground and lapped high carbon chrome steel makes each Torrington Needle Roller a precision part for long life performance.

Close tolerances are assured by stringent quality controls. Standard OD tolerance is .0002", but Torrington Needle Rollers can be supplied with tolerance of .00005". Tolerance on length depends on end shape.

Fine finish reduces friction to a minimum. Torrington Needle Rollers are usually polished to 4-6 rms, but finishes as fine as 1-3 are available on special order.

Now you can get highest capacity at lowest cost with Torrington Needle Rollers

A hardened shaft, a hardened housing, and precision Torrington Needle Rollers provide the most economical, highest capacity antifriction assembly you can obtain.

Six roller end shapes permit design flexibility whether the requirement be maximum effective roller length, proper fillet clearances or greater lip retainment. Torrington Needle Rollers are available in a complete line meeting SAE and AFBMA specifications. Torrington standards for material, heat treat, tolerance and finish of Needle Rollers are the highest in the industry.

Operating results with Needle Rollers depend on careful design of mating parts. Torrington's Engineering Department, with extensive experience in Needle Roller application, will be glad to give you technical advice on your needs. *The Torrington Company*, Torrington, Conn.—and South Bend 21, Ind.

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For the Sake of Argument

Reformers and RE-formers

Trouble with reformers is that they rarely re-form anything. To form an idea, a program, or a design is to create something; to bring into being a concept or an object. To re-form, then, must be to form over again, to recreate.

But those dubbed reformers have usually torn down more than they have built up; destroyed more than they have created. Carrie Nation with her little hatchet is all too accurate a prototype of those with an urge to make man over in their own images.

True, a reformer does sometimes clear slum areas long resident in the minds of his contemporaries. He does, on occasion, level the tenement-ideas which must be razed before good thinking can spread its light. But his emphasis tends to be heavy on what ought to be stopped; light on exactly what ought to be started. Clobbering the evil-doer seems often the preferred route toward a never-attained collaboration with good.

The reformer may so concentrate on destroying the appearances of evil that he never touches the minds and hearts of men . . . where true re-forming must take place, if at all. Infrequently do those known as reformers participate in "the definition and affirmation of spiritual values," which, Erwin D. Canham says, are "a central and indispensable factor in the awakening of human thought."

The Great Re-former's concern was with what men thought. He knew that what they did was a result, not a cause.

There's more than a little of the reformer in most of us . . . which needs to be re-formed before we let it loose on our associates.

Norman G. Shidle

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ON POWER BRAKING

. . . the overwhelming choice on trucks

is vacuum power,

with Hydrovac* leading all other makes combined.

Users prefer this kind of braking because

—it does the job simpler

—and better

with less first cost,

less expense for maintenance.

Then, by saving weight,

it can add several hundred pounds to pay load.

All this plus . . . the vital safety in having

physical braking instantly available

should power fail for any reason.

. . . It will pay to investigate

HYDROVAC (VACUUM HYDRAULIC) POWER BRAKING BY BENDIX

* REG. U. S. PAT. OFF.

Bendix PRODUCTS DIVISION South Bend, IND.

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chips

from SAE meetings, members, and committees

IN HIS LUNCHEON TALK during Annual Meeting, Del Harder of Ford made the following remark: "If an apple fell on a UNIVAC instead of Sir Isaac Newton's head, it might have blown a tube in the UNIVAC, but the UNIVAC never would have come up with the law of gravity."

Most of us would be further along if we spent more time getting into habits and less trying to get out of them.

NEW YORK STATE MOTORISTS will be paying a total of 10½ cents tax on every gallon of gasoline they buy if the Federal Government adds an additional 1½ cents per gallon as proposed. (New York State recently approved a 2 cents per gallon increase effective March 1.) The 10½ cents sales tax represents about 44% of the retail price of regular gasoline.

A "SPECIAL BLUE INSTRUMENT CARD" was presented recently to assistant chief of pilot training of PAA's Atlantic Division (William W. Moss). The card is light blue in color. It has two holes in it. It carries this legend:

"This card is for use by aviators of the higher echelons who, as time goes by, are becoming more and more familiar with the mechanics of paper shuffling and less familiar with the mechanics of flying . . . (1) Hold the card up to sky . . . (2) Look through the holes. If the color of sky matches color of card, it is safe to fly. File your flight plan."

Refrigeration ENGINEERING still uses the "Roman Snow" method in some vehicles. Wealthy Roman citizens kept up with the Joneses by having fresh Alpine snow for dessert delivered by fast running slave. The efficiency of this system depended on the slave running faster than the heat could ruin the load. Varieties of this method are still used today without the Roman advantage of running down hill all the way.

INCREASED HORSEPOWER and accident frequency are not directly proportional, despite the many criticisms leveled at industry. The accident rate per vehicle per mile continues to fall while the average vehicle horsepower is increasing. Today, in *low* horsepower Europe there are more fatal accidents than in *high* horsepower America.

ARE YOU TROUBLED WITH DESIGN CHANGES? Well check your changes against the rates reported for a 12-month period of ground support equipment development for the Redstone missile. A change was processed each 15 minutes and 22 seconds, day and night for 365 days. At any one time 200–300 of these changes were "in the float."

"CHARGE STRATIFICATION" cuts down on gasoline consumption in automotive engines. It involves injection of a "rich" mixture of gasoline and air near the spark plug and a "lean" mixture in the rest of the cylinder. Using identical fuels, air-fuel ratios as high as 42/1, compared to today's 15/1, have been obtained without engine knock. A major obstacle is the development of suitable fuel injectors.

"INSTEAD OF sprayed-on surface paints, the car of 1980 could have tinted oxide film coating, a 'color-filled' metal surface which would never require polishing or repainting." . . . So says Plymouth's J. E. Charipar.

Almost everybody gets satisfaction from doing a favor. Almost nobody likes to do someone's else work.

CONSTERNATION caused the SAE Handbook printer to call to say: "These plates you're using with that revised report called "Determination of Inclusions in Steels" have dirty spots on them. . . . Didn't you even notice the spots on the proofs!"

It took a while to convince him that those "dirty spots" were really 100-times magnified illustrations of the inclusions . . . and that the Iron and Steel Technical Committee would be kinda annoyed if we "cleaned them up."

Today's Measurement Units

Based on paper by

Allen V. Astin

National Bureau of Standards

MAN is outgrowing, and dissatisfied with, present units of measurement. They're inadequately precise. New techniques of measuring are being developed not merely to evaluate physical properties but for broader understanding of materials and creation of better designs and products.

Let us look at some of the scientific and technological categories that present current examples of measurement frontiers. In the area of the newer basic scientific investigations, some may recall the nuclear parity experiment of last year which provided confirmation to the hypothesis of the Nobel laureates, Lee and Yang, that a long-held theory of nuclear symmetry had questionable validity. Professors Lee and Yang proposed some experiments to test the theory.

It then became a complex and delicate measurement problem which had to be solved in a decisive way. This required the capabilities of scientific specialists who could undertake precision measurement in a number of disciplines. The experiment took about six months to set up, run, and analyze.

Here is a case where precise measurement at a frontier of basic science gave new understanding. This reversal of a long-held physical theory is expected to contribute towards the unraveling of confusing data and speculation regarding the large number of fundamental nuclear particles. Today's confusion has been compounded by seemingly contradictory observations. In this field, novel measurement techniques have been developed, but even geater ingenuity and precision is required to break through the present nuclear puzzle.

plasma physics

Another interesting basic frontier of measurement exists in the field of ionizing radiation. Lately the phenomena of ionized gases have been the subject of intense exploration for they show promise as sources of tremendous power and of serving as envelopes for large natural furnaces. It is apparent, however, that in this field theory is running well ahead of measurement capabilities. The obstacle to significant experimentation in this area is the lag in the development of precise techniques for producing and controlling these phenomena in a laboratory. Although we recognize that there are tremendous heats and energies locked in these materials, we must treat the problem in relatively broad experiments until we achieve further advances in instrumentation.

Still another area of basic interest, possibly related to that of plasma physics, is the field of "free radicals." About 5 yr ago, it was definitely established that highly unstable molecular fragments exist for minute fractions of time in nature. Up until recently, this phenomenon could not be adequately observed. Now we are in a better instrumented position not only to observe, but also to capture and create these fragments. Having come this far, we are still perplexed by the phenomena we are observing. This is a real problem for measurement specialists, and there is a substantial effort in this direction.

In the basic measurement area, the National Bureau of Standards is spearheading a large cooperative effort, including a number of scientists from industry, to measure these phenomena in the laboratory. Free radicals have opened up vast possibilities for new studies of the molecular binding characteristics of nature and of untapped chemical energy sources. The measurement of these phenomena has been especially difficult, and substantial progress is directly dependent upon future refinement of our measurement techniques.

science measurement frontiers

In the established fields of science, we also come up against some difficult measurement frontiers. Here, despite significant measurement advances, we are faced with the continuing challenge for greater precision. And it is characteristic of this need that further progress is often most difficult, for having reached certain levels of measurement sophistication, further progress requires an extensive effort.

Consider the broad field of spectroscopy where advances in precision techniques have already provided the basis for most of our knowledge of molecular, atomic, and nuclear structure. In spite of the great strides which have been made there are many problems whose solution would be accelerated by improved techniques of measurement, such as in beta ray, spectroscopy, or infrared spectroscopy.

A second example concerns time measurement techniques. Cesium beam and related devices, and masers are providing new opportunities for the accurate measurement of phenomena occurring in extremely short intervals or very minute changes of certain processes over longer periods. It may soon be possible to put a sensitive atomic clock in a satellite to check the influence of gravitional field on atomic processes.

Are Passé

Another vital frontier is that of temperature, especially the extremes of temperature. Today's requirements for high-temperature materials, high speeds and frictions, and increasing propulsion efficiencies have placed a premium on the extension of the temperature scale. Today's research requires instrumentation for making laboratory and field experiments on high-heat systems under operating conditions. Here again is a case in which theoretical studies have advanced beyond precision-measurement capabilities. Under controlled laboratory conditions, we can make high temperature measurements with some confidence up to about 6000 C, yet today we are talking about million degree temperatures and we hear of the possibility of controlled fusion furnaces.

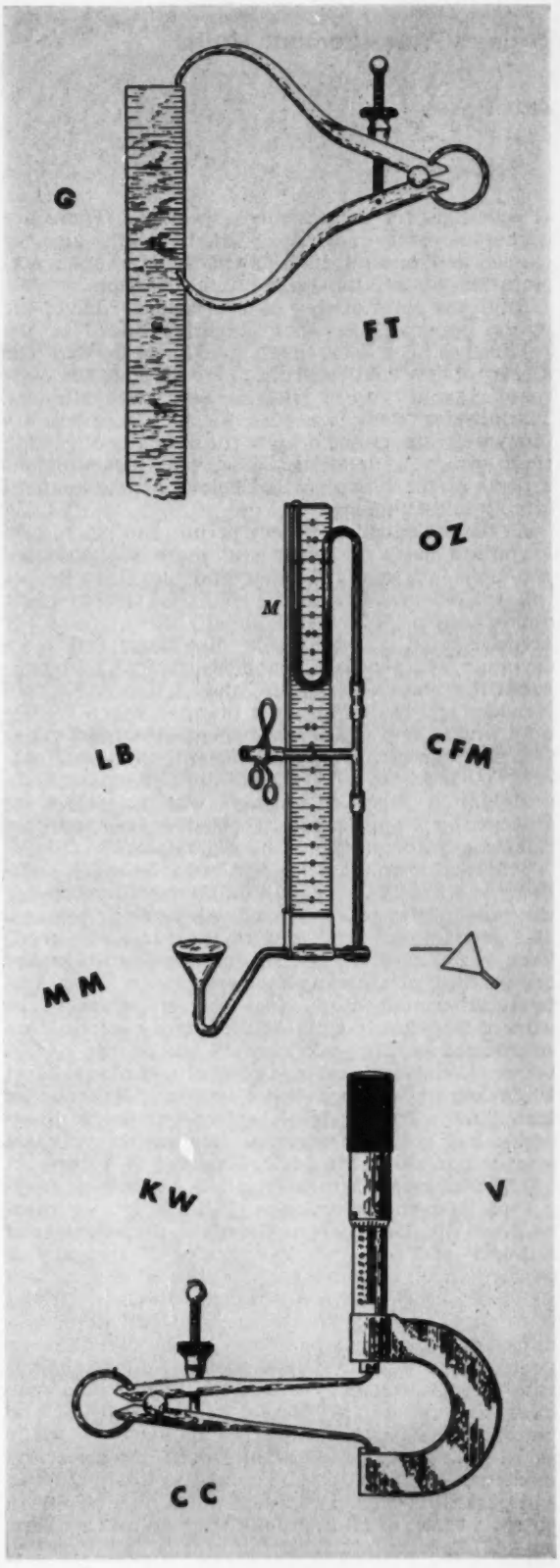
At the other end of the temperature scale, there is a similar measurement challenge. Below 4 deg abs, there lies the vast field of cryogenic research and prospects of low-temperature production processes, yet there are no fully adequate reference points in this segment of the temperature scale. Cryogenic temperatures povide us with a new way of studying normal phenomena. For this reason nuclear physicists, physicists, metallurgists, chemists, and engineers have entered into the field of low-temperature investigation. Yet these studies have hit discouraging and confusing snags because of the lack of these reference points and the inadequate precisions in today's low-temperature measurement techniques.

One more measurement frontier of current interest is the field of highly pure substances and materials. It has become necessary to devise precision production and analytic techniques so as to exceed previously attainable purities, in some cases by two orders of magnitude. In addition, it looks like the new measurement and control techniques will have to be suitable for large-scale production processes.

Usually in these established fields of science the measurement science lags behind the need. Very often the demand builds up to a point where the requirement for measurement advances and new instrumentation no longer can be resisted. In some ways this is unfortunate. Answering crash requirements is not the best way to solve perplexing measurement problems.

newer areas of technology

In the newer areas of technology, the examples just given could well be included because these are areas where technologists press closely on the heels



Today's Measurement Units Are Passé

. . . continued

of scientists for more basic knowledge. There are numerous other activities which might also be classed as frontiers, such as the fields of space exploration, automation, and miniaturization.

From the point of view of basic science, one of the major opportunities that satellites afford is the placing of a measurement platform beyond the screen of the earth's atmosphere so that the universe may be viewed without restrictive blinders. The physical devices needed for such research are fairly well understood despite the difficulty of getting them properly launched. So, the measurement aspects of space exploration belong at the moment largely to technology.

As technological advances permit the placing on a routine basis of larger and more sophisticated satellites into orbit, or lunar and planetary probes into trajectory, there will be countless measurement opportunities. These undoubtedly will increase our knowledge in unpredictable directions and most certainly will generate new measurement problems. From the point of scientific observation one would consider the launching of a manned space vehicle only when there is a measurement or control function that can be made more efficiently and economically by man than by automatic instruments. In anticipation that this stage will sometime be reached, it is appropriate to consider soon possible solutions to the placing of man in space.

The field of automation has received much comment in recent years. Many industries are studying the possibilities of automated processes in business and production. The uses of measurement, feedback, and control for flexible mass production makes the promise of automation a bright one. Measurement instrumentation, however, still has to be worked out for specific applications. Automation equipment is more often than not in the design stage. Computational and control techniques must be developed. And a rational system of interrelated instrumentation for total automated control processing has not been created. Thus there still is a most important technological frontier to subdue.

The field of miniaturization is essentially a product of modern technology. Today's devices must be made up of many components and subdevices of reduced size but with no sacrifice of accuracy or performance. Achieving reductions of weight and size is an important measurement problem. It has been noted that the successful miniaturization of a device often is accompanied by longer life than its normal counterpart. This is probably due to the advanced measurement techniques required to produce the mite. The pivots, bearings, gears, and clutches that are essential components in many small instruments demand unusual fabrication and measurement. Controlling precision to one part in a thousand is obviously much more difficult on an object a tenth of an inch long than on an inch long object. Because miniaturization is so important to the future of instrumentation, it has double significance as a measurement frontier.

established technology

The area of established technology is populated with changing measurement frontiers of new products and new production processes. Let us consider three special problems — reliability, force measurement, and length measurement.

Component reliability is a problem as old as technology itself and as new as tomorrow's product. Recently the problem has increased in severity because technology has come to depend more and more upon a complex network of interrelated devices made up of thousands of components and hundreds of thousands of parts. When it is considered that the malfunction of a unit may detract from the operation of the system, we become aware of the need for a rational approach to reliability. We must reexamine our notions of quality control, inspection, and precision measurement. We may have to rely upon continuously controlled production processes with the same degree of intricacy of machine inspection that can be expected in a total system after assembly. Here is a problem which design and structural engineer must cooperate in so that fundamental reliability can be built into unit parts in anticipation of ultimate use in complex systems.

In the field of force measurement we find another frontier. Military agencies and space exploration are requiring initial thrusts approaching that of a million pounds and probably will exceed that requirement in the near future. Furthermore the devices for which such thrusts are needed also require that the force measuring devices be calibrated with precision acucracy. Unfortunately, this is another case where the demand has far preceded the measurement capability. Today, we can only provide direct comparison of force measuring devices with dead weight standards to a little over 100,000 lb, about one-tenth of the requirement. The problem of providing indirect comparison and calibration services is indeed a measurement frontier.

The final example comes from linear metrology. Here, because of strong pressures from industry, we are seeking improvements in gaging, calibration techniques, line standards, and end standards. We are moving away from arbitrary physical standards towards a dependence on natural atomic constants. The time will come when the basic standards of length, mass, and time will be defined with greater precision in terms of natural constants.

We are presently in a period of transition leading towards the establishment of basic standards of length and time defined according to specific atomic constants. By 1960, if the international convention of nations adhering to the Treaty of the Meter acts as expected, the meter will be defined in terms of krypton 86. On the working level of linear measurement, the National Bureau of Standards has been cooperating with industry in improving linear calibration devices. The Bureau hopes to be in a position to calibrate master devices to one ten-millionth of an inch. This will enable production line tolerances of one one-hundred-thousandth of an inch.

To Order Paper No. 21R . . .
. . . on which this article is based, turn to page 6.

PAA's experience with

B-707 shows . . . . .

Speedup in Jet Flight Training

Based on talk by

W. W. Moss

Pan American World Airways

FUTURE training will probably show that an adequate checkout — including type rating — on jet transports can be done in 9–10 hr at the most. . . . about 2 hr more than the standard time for piston-powered equipment. This estimate grows out of PAA experiences in type-rating qualification of nine supervisory captains and some training of a few more, for a total of approximately 115 hr of training during approximately 90 hr of continental and intercontinental flights.

In these first training experiences the average time was considerably above this 9–10-hr estimate, but resulted from a combination of influences that would not be present in later, standardized training-for-checkout procedures. For one thing, the pilots who participated in the 115 hr of training were "desk pilots." While their inherent ability is high, their recent flight experience is low. . . . Also, numerous airports were used for this training — and some time was used unproductively enroute to and from these. . . . And, finally, PAA was feeling its way as to just how it wished this Boeing 707 to be flown in airline service as distinguished from the limits to which the aircraft could be safely flown. (Due to the tremendous maneuverability and flexibility of the B-707, there is a marked difference between what is technically feasible and what is acceptable to the traveling public.)

But, as indicated, it is likely to take about 2 hr longer to train a jet transport pilot than is normal for training the same man for piston-powered equipment.

The extra time will go largely into maneuvers necessary in training for jets which are over and above (or are treated differently from) those to which we have been accustomed in the past. These will include:

1. *Recovery from dutch roll:* The lateral-directional control relationship of this aircraft is such that a considerable amount of practice should be spent on it. This time is amply repaid later during take-offs and landings, when this rudder-aileron relationship becomes very important.

2. *High altitude airwork — a dive to Mne (Mach number never to be exceeded) — and emergency descent to 1500 ft:* The 30,000-ft climb involved here is time well spent. It gives the pilot an appreciation of the "real estate" required for maneuvering at high altitude; permits demonstration of the mild "tuck under" control characteristic above 0.85 Mach; and a realistic run-through of the emergency descent maneuver.

3. *Stalls, approaches to stalls, and zero rate of climb speed demonstration:* Stall demonstrations are not new — only the emphasis has changed. This aircraft's stall warning is so unmistakable and buffet at full-stall so intense that only two complete demonstrations are allotted — one clean and one dirty. Thereafter the focus is on approaches to stalls, going 3–4 knots into the buffet and recovering with minimum altitude loss. Ample speed margin between V_2 and the zero rate of climb speed is stressed . . . and attention fixed on the rate of climb with any lessening of speed below V_2.

4. *Landings:* Besides the usual 3– and 2-engine landings, a spoiler landing is demonstrated — with outboard flaps (and ailerons) inoperative and the adjustable stabilizer jammed in nose-down position. Here the inboard spoilers are rendered inoperative and outboad spoilers upped 30 deg to cause a sufficient nose-up pitching movement for ample elevator control in landing with 40-deg flaps.

Time must be spent on landings to assure precise speed control at runway threshold . . . also to provide the pilot with the instinctive know-how to up the spoilers immediately after touchdown, and activate the reverse thrust.

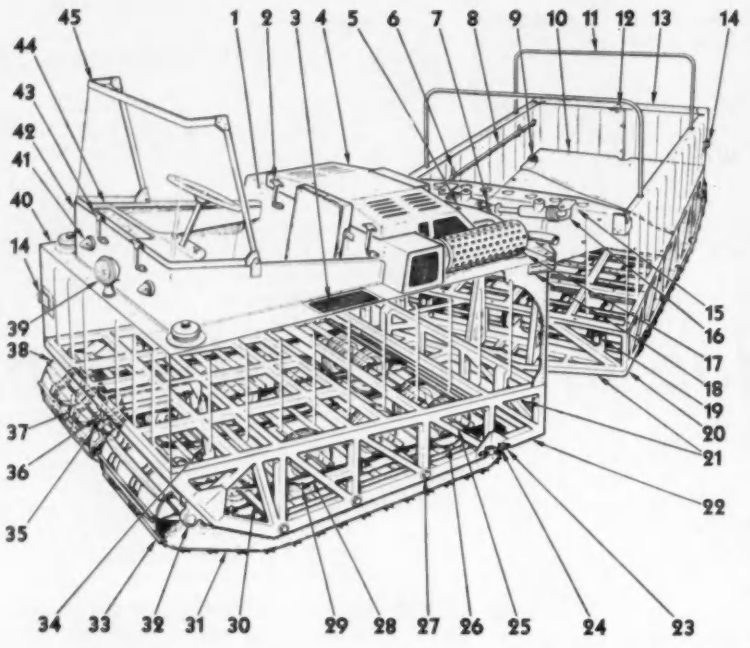

1 ENGINE COMPARTMENT BULKHEAD
2 ENGINE HOOD FASTENER
3 FOOTSTEP
4 ENGINE HOOD
5 UPPER FORWARD ARTICULATION BEAM
6 ENGINE STARTING CRANK CLIPS (THREE)
7 SHOCK ABSORBER FORWARD ATTACHMENT
8 ENGINE STARTING CRANK
9 CARGO TIE-DOWN RING (FOUR)
10 FLOOR COVERING
11 CARGO COVER SUPPORTS (TWO)
12 REAR LIGHT
13 REAR BODY UNIT
14 PARACHUTE ATTACHMENT LUGS (FOUR PER UNIT)
15 UPPER REAR ARTICULATION BEAM
16 SHOCK ABSORBER REAR ATTACHMENTS
17 EXHAUST MUFFLER BRACKETS (TWO)
18 ARTICULATION BEAM ATTACHMENT BRACKETS
19 STEERING PULLEY ASSEMBLY BRACKET (FOUR)
20 REAR CHASSIS UNIT
21 LOWER ARTICULATION BEAMS
22 FORWARD CHASSIS UNIT
23 TRACK TENSION ADJUSTER LUG
24 TRACK TENSION ADJUSTER
25 IDLER AXLE
26 IDLER WHEELS (FOUR PER UNIT)
27 AXLE ATTACHMENT BOLTS (EIGHT PER UNIT)
28 ROAD WHEELS (SIX PER UNIT)
29 WHEEL GUIDE CONES
30 ROAD WHEEL AXLE (THREE PER UNIT)
31 LH TRACK
32 DRIVE AXLE BEARING HOUSING (TWO PER UNIT)
33 GROUSERS (32 PER TRACK)
34 SUPPORT BRACKET (ONE PER UNIT)
35 TOWING ATTACHMENT PIN (ONE PER UNIT)
36 TOWING ATTACHMENT LUG (ONE PER UNIT)
37 SPROCKETS (FOUR PER UNIT)
38 RH TRACK
39 SPOTLIGHT
40 FORWARD BODY UNIT
41 DRIVING LIGHT (TWO)
42 BODY COAMING
43 WINDSHIELDS FASTENERS (TWO)
44 DASHBOARD STRUCTURE
45 WINDSHIELD

Fig. 1 — Chassis of each unit consists of two side frames joined together by a horizontal grid work on the upper edge, and four tubular axles joining the lower members.

Designed for airborne delivery and use in extreme

Canadian Army's

Excerpts from paper by **L. J. Stypinski** Canadair, Ltd

THE RAT, Canadian Army's recently developed light, tracked vehicle, is designed to carry a load and to tow infantry sleds and toboggans over snow and ice and barren wastes. It can cross rivers and medium-sized lakes, and is suitable for amphibious landings.

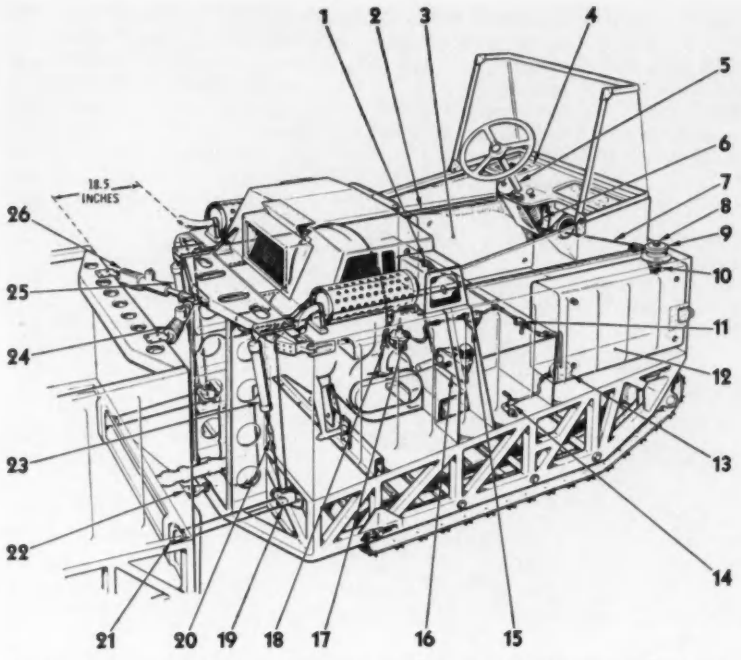
Design parameters for the RAT's structure were greatly influenced by the requirements of air dropping techniques. Its maximum size, for example, was dictated with air transportation and air delivery in mind.

These and other considerations resulted in the RAT's being an articulated, fully tracked, amphibious vehicle capable of operating under extreme winter and summer conditions. The method of steering by articulation and the very low ground bearing pressure eliminated the inherent instability common to some other types of track-laying vehicle. Absence of suspension in the standard model restricts the RAT to operations on a predominantly soft surface, and caution must be exercised when high-speed driving is attempted on bumpy ground.

The RAT's ground pressure of ½ psi is the lowest ever achieved in any power driven unit. It is equivalent to the pressure of a man on a pair of snow skis, so it is true to say that wherever a skier can go, so can the RAT.

This low ground pressure was achieved by careful design and extensive use of aluminum alloys where possible.

The tracks are designed to cover full width of the vehicle, which makes it bellyless and adds greatly to its mobility. The tracks themselves follow the principle of the space-link track design, which takes advantage of the arching effect of soil or snow in supporting spaced track in the same way as if it had a continuous surface. The added advantage of this



1 FUEL SELECTOR COCK - LH
2 STEERING CABLE - LH
3 FUEL TANK - LH
4 COLD START PROCEDURE CHART
5 STEERING COLUMN
6 SPIRAL DRUM
7 STEERING CABLE - RH
8 FUEL FILLER CAP ADJUSTABLE VENT (TWO)
9 FUEL FILLER CAP (TWO)
10 FUEL TANK SCREEN (TWO)
11 FUEL SELECTOR COCK - RH
12 FUEL TANK - RH
13 WATER TRAP (TWO)
14 FUEL TANK DRAIN COCK (TWO)
15 FUEL LINE FILTER
16 COLD START MECHANISM
17 ENGINE FUEL PUMP
18 COLD START INDUCTION ADAPTER - RH
19 STEERING PULLEY SWIVEL MOUNT - FORWARD
20 STEERING CABLE TURNBUCKLE (TWO)
21 STEERING PULLEY SWIVEL MOUNT - REAR
22 LOWER ARTICULATION COUPLING
23 STEERING CABLE SPRING BOX - RH
24 SHOCK ABSORBER - RH
25 STEERING CABLE SPRING BOX - LH
26 SHOCK ABSORBER - LH

Fig. 2 — Steering is effected by controlling the angle of articulation between the front and rear units. This is accomplished by a cable and pulley arrangement.

Abridgment of an
SAE Montreal Section Paper

winter and summer conditions is the

new RAT

design is that the spaces tend to increase traction.

Design of the track and steering results also in greatly increased drawbar pull, a factor that has not been improved in orthodox vehicles for many years. In sand, for instance, the drawbar pull of the RAT is equivalent to about 110% of the vehicle's weight, while a well-designed single-unit vehicle can only pull an equivalent of approximately 70% of its own weight. With the differential steering on a single unit vehicle, there is a practical limit to the area of the tracks in contact with the ground.

The length of such a vehicle is limited by its ability to steer. And to increase its width is also impractical, since increasing frontal resistance will soon offset any advantage. It is true of any medium, be it air, water, or snow, that it is better to increase the length rather than the width of an object moving at subsonic speeds. Few ski races would be won using water skis.

The articulated principle imposes practically no limit to the length of the tracks; hence the large

AIR DELIVERY and air transportation were much in the minds of designers of the RAT, because this recent Canadian Army vehicle is primarily for carrying loads and towing infantry sleds and toboggans over the snow-covered, barren terrain of the North.

So, many of the same design considerations were involved as in the BAT and the ABC, newest projected members of the U. S. Army's airborne family. The story of these two U. S. Army vehicles was told in SAE Journal's November, 1958, issue, starting on p. 52.

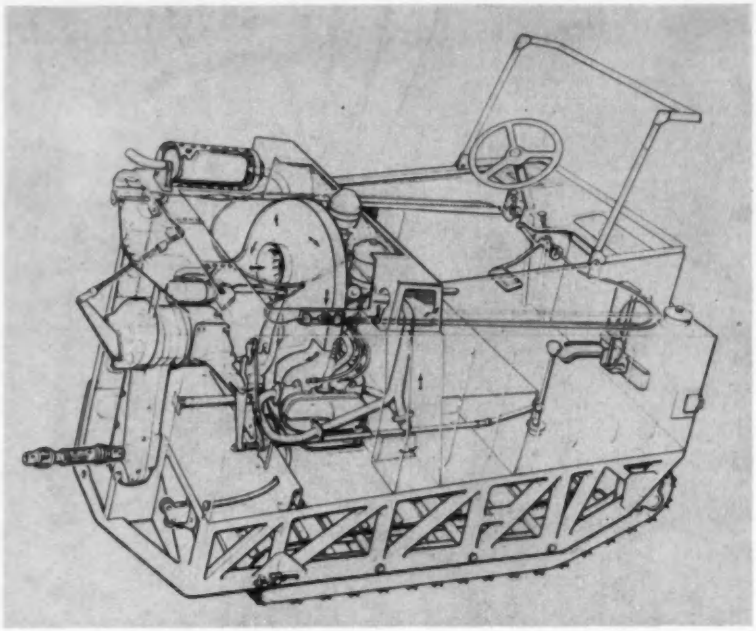


Fig. 3 — The engine is a standard unit, developing 35 hp, but has been modified slightly to operate successfully in the RAT.

Canadian Army's new RAT

. . . continued

contact area with the ground, which increases the traction and reduces the unit pressure.

With the articulated steering principle, all tracks move at the same speed at all times, so that bogging down, so common with other vehicles, does not occur when turning is attempted in snow, mud, or muskeg. Due to lack of relative slip between the tracks, the articulated vehicle is extremely stable no matter how rough the terrain over which it travels. This is particularly noticeable in entering or leaving water obstacles, and during other maneuvers when the vehicle may be momentarily supported on part of the track only — such as when traversing boulders, tree trunks, or steep snow banks.

General Arrangement

The RAT consists of two driven units in tandem configuration, joined together, but having freedom to articulate within designed tolerances.

The first unit accommodates driver, engine, main transmission, and the fuel tanks.

The rear unit is left clear for cargo carrying. The dimensions of the floor space on the rear unit are 4 ft by 5½ ft.

The two units are connected by a ball joint located on the centerline below the floor level, and between the two units.

The amount of relative angular displacement between the two units is restricted in the three principal planes to a designed degree by the hydraulic dampers and the articulation beams located at top of the structure. These limit the movement to 80 deg included angle in the horizontal plane and to 5 deg in sag, 10 deg in hog, and 7 deg in relative roll. This arrangement allows the vehicle to mold itself into terrain for maximum traction and also to cross small ditches and other hazards by bridging them.

Steering of the vehicle is effected by displacement of one unit in relation to the other about the point of articulation.

The rolling resistance of the vehicle is such that no foot brake is necessary and the hand brake is intended for parking and emergency use only.

Chassis

The chassis of each unit (Fig. 1) consists of two side frames joined together by a horizontal grid work on the upper edge and four tubular axles joining the lower members. The axles form an integral part of the chassis. The lower members are also joined at one end by a triangular-shaped articulation beam.

Chassis and the engine mount are designed to 12*g* limit loads. Individual components, such as wheels, axles, and articulation beams, are designed in general to an acceleration factor of 3*g* and an ultimate factor of 2. The two chassis of a complete vehicle are joined "back to back" by the ball joint, which is located at the apex of articulation beams.

The body and chassis form an integral structural member and they share the loads imposed on them by the movement of the units.

Steering System

Steering of the vehicle (Fig. 2) is effected by controlling the angle of articulation between the front

and rear units. This is accomplished by means of a cable and pulley arrangement. The steering drum is mounted on the bottom of the steering column and takes in cable from one side of the vehicle and pays it out to the other, thus pulling a rear unit about the point of articulation. The drum is designed in the shape of a lemon so that the geometrical gain and loss in lengths of the cable during articulation is compensated for.

The Engine

Several engines were considered in the initial stages and various arrangements for the layout of the front unit were drawn. The Volkswagen engine satisfied the specifications, and, in addition, is easily avaliable in 90% of all civilized countries throughout the world.

The engine (Fig. 3) is a standard unit developing 35 hp, but it has been modified slightly to operate successfully in the specific application of the RAT.

The Power Transmission

The power from the engine is transmitted through a single dry plate clutch to a four-speed forward and one reverse manually operated gearbox, and from there by chain drive to a system of prop shafts. A spiral bevel gearbox transmits the power in the final stage to the sprocket axles on both the front and rear units. Two rubber covered sprockets are mounted on sprocket axles on each side of the final gear box. These sprockets drive the tracks by engaging with the track cross links, which are called grousers.

The power transmission was designed for operation at maximum input of 35 bhp at 3400 rpm and maximum torque of 56 ft-lb at 2200 rpm. The nominal design life of the transmission is 1000 hr calculated on the basis of continuous operation under maximum torque conditions. A shock load factor of two was introduced to take care of sudden clutch engagement, jerky starts with a heavy load, and beaching operations, which may cause an abrupt reduction of the track speed. This factor was applied to stressing gears, splined shafts, and the chain drive. Steady loads only were considered for establishing the bearing sizes, with the exception of the bearings in the spiral bevel gearboxes, where the axial loads were again factored. The main gearbox was designed for maximum life of 300 hr in each of the first and reverse gears and for 600 hr in each of the remaining gears.

Main Gearbox

Of necessity, the main gearbox is a very compact design since it had to be mounted at the back of the engine inside a relatively short engine compartment. The design is more or less conventional, and the four forward and one reverse gears are manually selected.

The final gearbox transfers a torque of approximately 1000 ft-lb through a spiral bevel crown gear and pinion giving 2.5/1 reduction ratio.

Tracks on both units are identical in design and they are fully interchangeable. Each track is constructed from three rubber conveyor-type belts joined by the grousers. In the fore and aft direction the tracks stretch between the sprockets (Fig. 4) and the idling wheels.

Air Dropping Technique

To permit a parachute aerial delivery of the RAT to the scene of operation required a specially designed energy absorption platform capable of arresting the total kinetic energy of the impact, which at 35 fps drop velocity amounts to some 30,000 ft-lb. After extensive investigations of several possible schemes and many laboratory and field tests, an air dropping platform was designed consisting of several fruit juice cans sandwiched between plywood boards. This platform arrested successfully the kinetic energy of the RAT during several parachute drops at the Rivers proving grounds at Manitoba. The deceleration on impact never exceeds 12*g*, which is the designed static load for structural yield governed by the strength of the engine beam.

To Order Paper No. S149 . . .
. . . on which this article is based, turn to page 6.

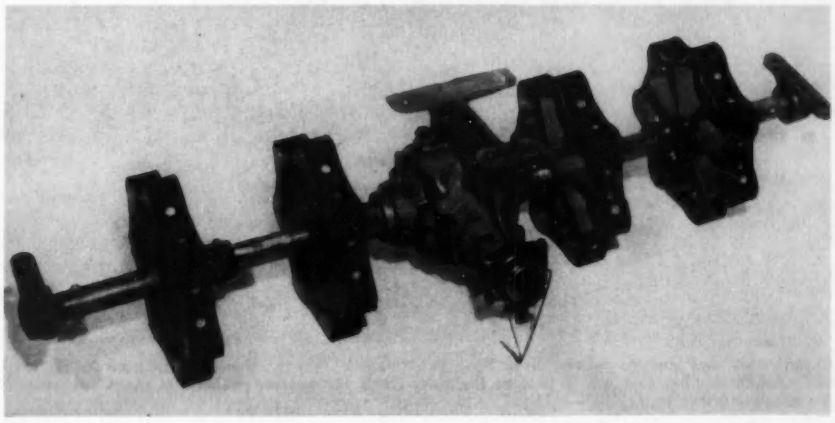


Fig. 4 — Tracks on both units are identical. In the fore and aft directions the tracks stretch between the sprockets and the idling wheels.

Involute Splines Give:

• Better fits. • Lower manufacturing costs.

• More accurate quality control.

Based on papers by

Leon N. DeVos, Ford Motor Co.

G. H. Sanborn, Fellows Gear Shaper Co.

and **A. S. Beam,** Vinco Corp.

INVOLUTE SPLINES enjoy three major advantages over their straight-sided counterparts:

- New design concepts have given a more rational approach to clearances and errors.
- Manufacturing is cheaper and more accurate.
- Gaging is simpler. As a result, the involute spline standard of SAE and the ASA continue to take precedence over the older straight-sided standards.

Design Advances

The concept of *effective* versus *actual* dimensions is one of the main design advantages of the involute standard. This concept overcomes the case where the teeth of an ideal external spline do not fit the spaces in an internal spline, even though each tooth has the same width as the mating space. The interference is caused by such errors as profile shape, pitch, out-of-roundness, and lead.

To allow the ideal spline contour to fit in any position, its teeth must be reduced in thickness by the amount of the interference illustrated in Fig. 1. The effective space width of the internal spline is equal to this reduced width, as shown in Fig. 2.

The same reasoning when applied to the external spline leads to the concept of effective tooth thickness of an external spline. This thickness is a dimension equal to the circular space width, on the pitch circle, of a theoretically perfect internal spline which would fit the external spline without clearance or interference.

The result of this concept gives individual *actual* spaces in the internal spline that are greater than the *effective* space width. The external spline is similar. These *effective* dimensions permit the construction of part specifications which are consistant with service requirements and provide the information needed for processing and control of splined parts. It is the effective dimensions that control the *fit* of two splines.

No such system has been standardized for straight-sided splines.

Manufacturing Advantages

The involute spline tooth can be cut by a generating action by a tool that itself is sharpened by a

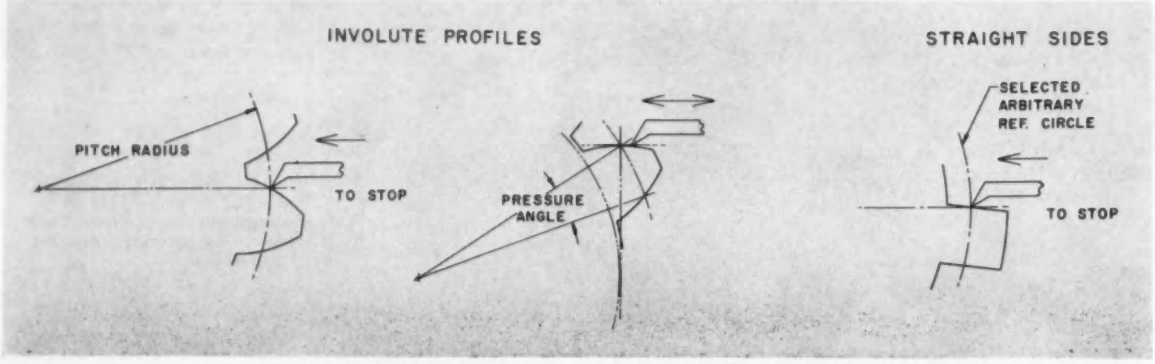


Fig. 3 — Gaging the tooth spacing of straight-sided and involute splines can be done with a probe. Two techniques are available for the involute form compared to one for the straight-sided form. The best way is to move the probe across the surface, as shown in the middle illustration, because it does not require the probe to jam into the tooth.

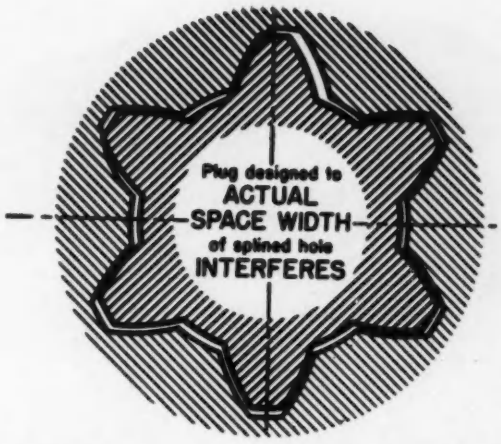


Fig. 1 — Splines may not engage even though there is an adequate hole for each tooth. Errors such as out-of-roundness and spacing can cause the interference. This means that the actual space width of an internal spline is not a true measure of the usability of the spline.

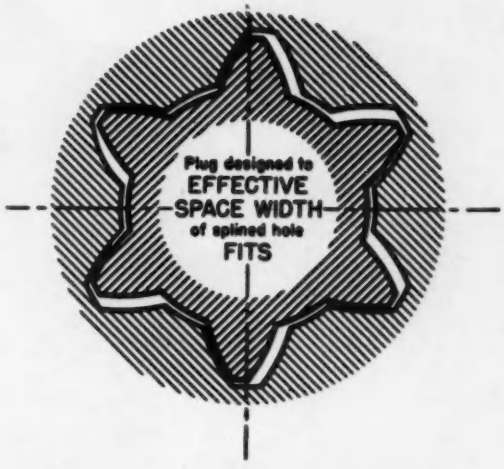


Fig. 2 — "Effective" space width of the internal spline is a true measure of the mating ability of splines. A corresponding concept can be used for the external spline.

generating action. This is not true of straight-sided splines. The two generating actions give high accuracy at low cost.

The following are comparisons of manufacturing techniques of the two types of splines:

Milling — One tooth is cut at a time with a form tool. This is slow and not sufficiently accurate for modern requirements. Straight-sided splines are often made this way because of the difficulty in generating them.

Shaping — There are two types, one where the tool and work rotate in mesh, called generating, and the other where a formed tool is fed radially into the work, called forming. In both cases the cutting action is by reciprocating motion. The involute spline can be generated with a tool that can be accurately sharpened, while a straight-sided spline needs a formed tool to generate the spline. This formed tool must be made as a composite of many different radii. Resharpening such a tool accurately is difficult.

Hobbing — The hob is, practically speaking, a straight-sided tool which does not change when sharpened back. As such it can be used to generate involute splines. Since the hob itself is generated ground, its shape can be held to 0.0001 or better throughout its life.

Rolling — Rolling is usually restricted to parts with 20 or more teeth. Because of this, it is not usually used for straight-sided splines.

Spline Gaging

Two types of gaging are used for splines. One is a functional inspection which determines the fit with a mating member. A composite spline gage is used for this inspection, and it checks the whole active spline contour. The other is an analytical inspection to cover specific characteristics such as spacing, profile, parallelism, space width, and tooth thickness.

The functional check is for production use while the analytical inspection is confined to prototypes, samples, evaluation of rejects, or critical tolerance requirements. Inspection of space width and tooth thickness by pins, paddle plugs, or snap rings forms a middle ground.

There is no difference between straight-sided and involute spline gaging when a functional check is made with composite plug and ring gages except that the gages themselves are harder to make for straight-sided splines.

The analytical measurements are often more restricted when measuring straight-sided splines than they are with involute splines.

Spacing — The spacing of both types of splines can be checked equally well by measuring the distance over pins placed between teeth. However, a probe indicator is restricted in its use on straight-sided splines. Fig. 3 shows that a probe can only measure by jamming to a stop on the surface of a straight-sided tooth. And this is not desirable.

Profile — There is no convenient method of checking the profile of straight-sided splines. In fact, if the sides aren't parallel, several possible methods are eliminated. This is because off center and spacing errors mask or accentuate the profile error. Involute splines are checked by machines that use the involute form itself as a means of checking the profile.

Parallelism — The same equipment and techniques are used for both types of splines.

Actual Space Width and Tooth Thickness — Pins and gages are used to check both types of splines.

To Order Paper Nos. 28R, 28S, 28T . . .
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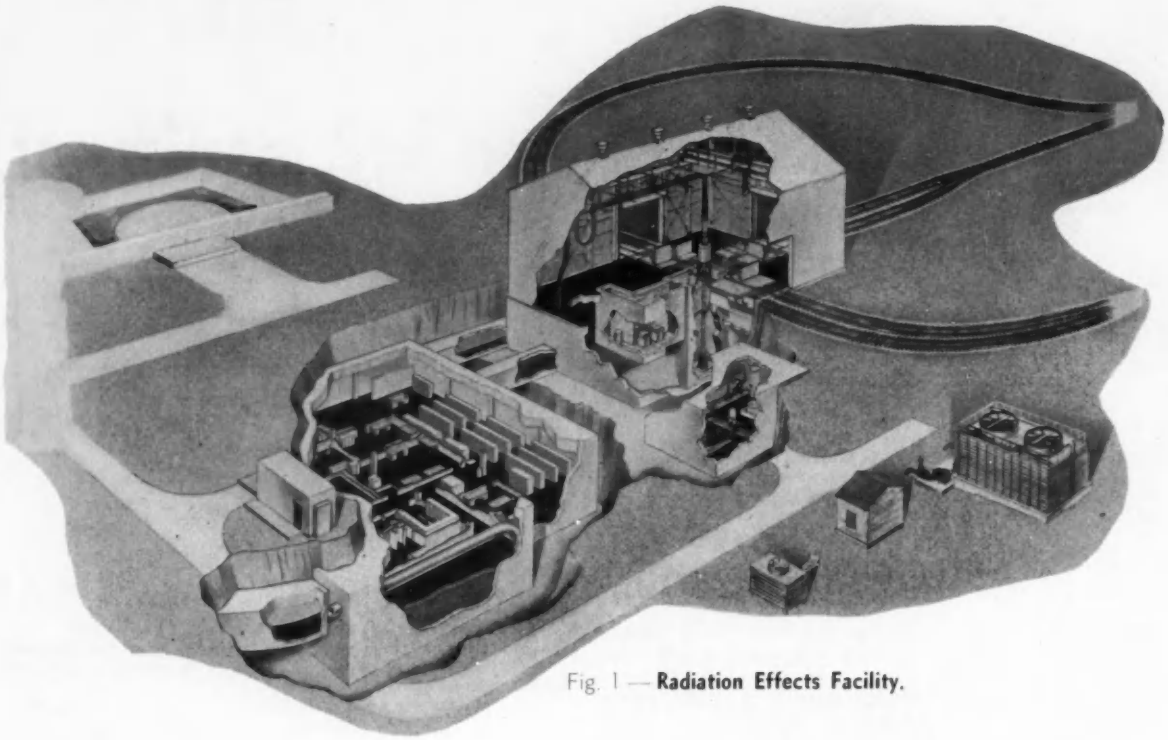

Fig. 1 — **Radiation Effects Facility.**

Lockheed's Georgia Will Accelerate ANP

Excerpts from paper by

W. R. Rhoads

Lockheed Nuclear Products, Lockheed Aircraft Corp.

LOCKHEED'S Georgia Nuclear Laboratory — being built to support the Air Force Aircraft Nuclear Propulsion Program — includes:

1. Radiation Effects Facility.
2. Radiation Effects Laboratory.
3. Hot Materials Transport System.
4. Critical Experiment Facility.
5. Nuclear Support Laboratory and miscellaneous support facilities.

Radiation Effects Facility

The heart of the Radiation Effects Facility (Fig. 1) is the Radiation Effects Reactor, shown in Fig. 2. This special research reactor was designed to provide realistic radiation fluxes, simulating both the spectra and energy levels of the radiation escaping from an aircraft reactor during long-range flights.

This reactor was designed to operate at 10 megawatts in order to minimize the amount of time necessary to apply the required total integrated radiation dose.

It is estimated that some of the aircraft subsystems to be tested may weigh several tons and occupy as much as 1500 cu ft of volume — for instance a main landing gear assembly for a large aircraft. Hence, it was necessary to design a reactor that provides test volumes far in excess of anything heretofore attempted. Furthermore, since the total number of systems to be tested is large, it was necessary to design the facilities to provide easy access and rapid instrumentation and test setup, in order to cut down the amount of time required for each series of tests.

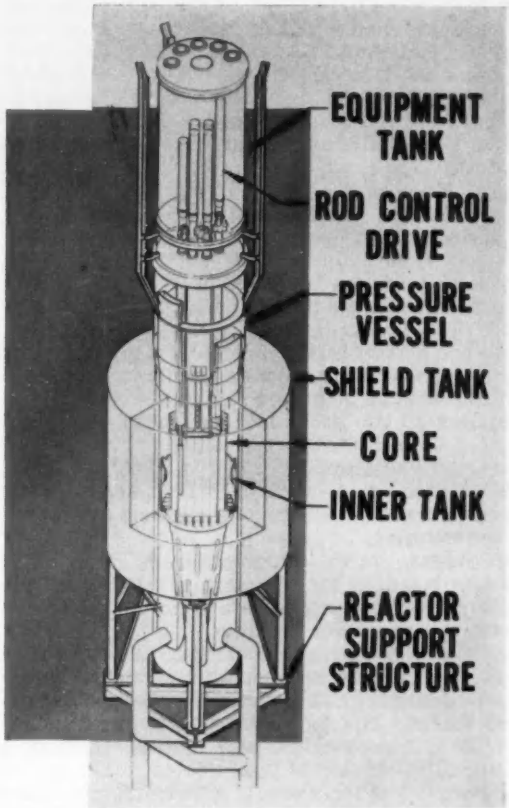

Fig. 2 — **Radiation Effects Reactor** was specially designed to provide realistic radiation fluxes, simulating both spectra and energy levels of radiation escaping from aircraft reactor during long-range flights.

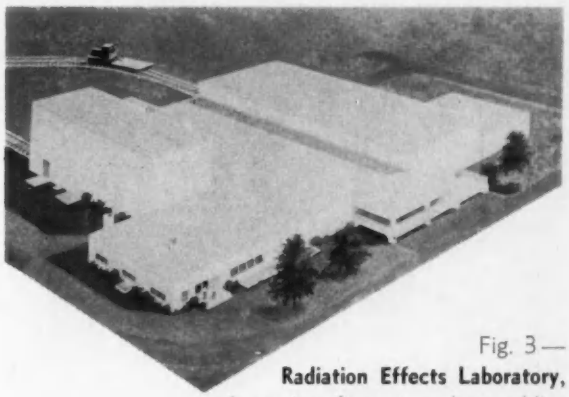

Fig. 3 — **Radiation Effects Laboratory,** where aircraft parts and assemblies are prepared for irradiation, instrumented, and given pre-irradiation tests of various kinds.

Nuclear Lab Program

The facility was designed for the dynamic operation of subsystems, various types of equipment, and components while undergoing irradiation, for the rapid handling of irradiated and activated material, and for the detailed analysis of the results of the irradiation.

Fig. 2 illustrates the most important features of the Radiation Effects Reactor. This is a light-water-cooled, moderated, and reflected reactor using MTR flat-plate fuel elements. It is slightly pressurized and is provided with an auxiliary shield tank, which permits the reactor operator to vary the amount and type of radiation leaking out into the test space surrounding the reactor assembly. This shielding tank is divided into four segmental compartments, each of which is subdivided into two annular shield tanks. These separate tanks can be remotely filled and drained with liquid shielding materials, such as borated water. When not operating, the reactor is stored in a pool so that the center of the core is posi-

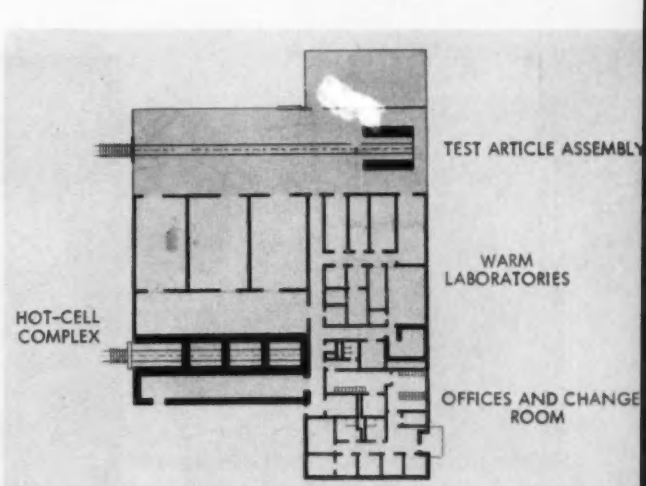

Fig. 4 — **Floor plan of Radiation Effects Laboratory,** showing four main working areas.

Lockheed's Georgia Nuclear Lab Will Accelerate ANP Program

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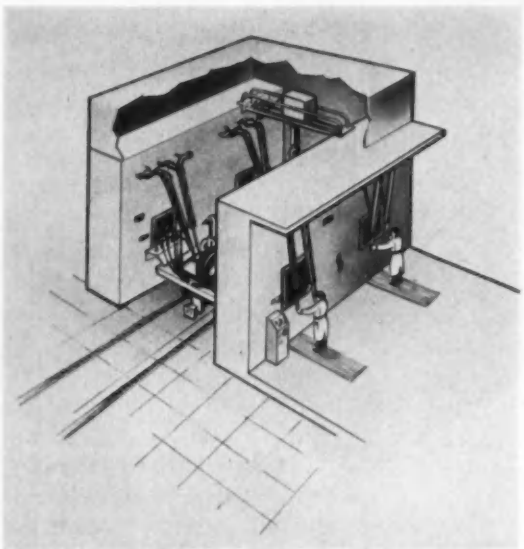

Fig. 5 — **Hot cell mockup,** used for disassembly check of test article prior to irradiation.

tioned 20 ft below the surface of the pool. The pool itself contains demineralized water, which is constantly circulated and scavenged. Before the reactor is operated, it is raised by means of a hydraulic lift to a position such that the center of the core is 10 ft above the suface of the pool.

In Fig. 1 the Radiation Effects Reactor is shown in its operating position, raised above the surface of the pool. The pool is separated into two sections by a watertight gate. This permits either section to be filled or drained independently. The reactor section of the pool is 40 ft deep. The other section of the pool is used for storage of spent fuel elements, and for temporary storage of reactor parts during maintenance operations.

While the reactor is shut down and is in the stowed position in the pool, the test assemblies mounted on small test cars can be moved into or out of the reactor building on the three pairs of tracks shown approaching the reactor on three sides.

The reactor building consists of a steel framework and corrugated sheet aluminum. The purpose of the building is to protect the reactor and test assemblies from the weather.

The pumps, valves demineralizers, and other equipment required for the primary cooling system for the reactor are located in a concrete pit buried adjacent to the reactor building.

All operations during test periods are controlled from the buried operations building. Normal access to this building is gained through an entrance tunnel 500 ft long. Air for ventilation is brought into the building from a point 4000 ft away through a large duct.

The reactor control console and instruments are located on the upper level of this building. There is also a large group of amplifier racks for test instruments and controls for the test assemblies undergoing irradiation. The rest of the upper level of this building provides data reduction offices, a small maintenance shop, and a change room.

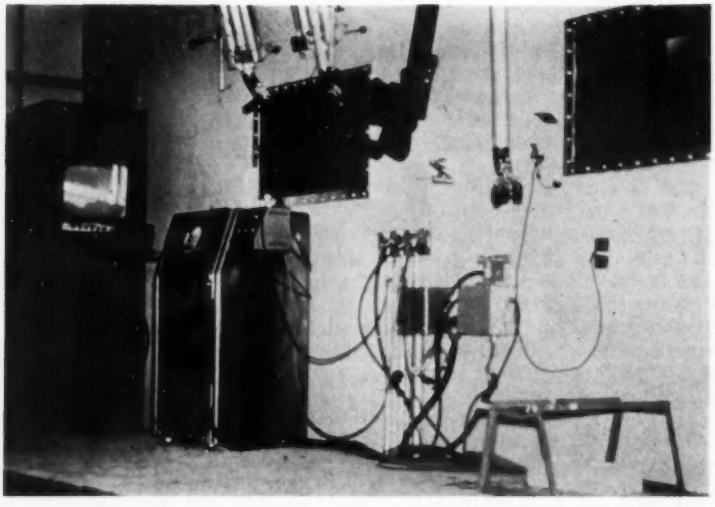

Fig. 6 — **Hot cell mockup,** showing controls for Argonne Model 8 type manipulators and General Mills bridge type manipulator, such as are used in actual hot cell.

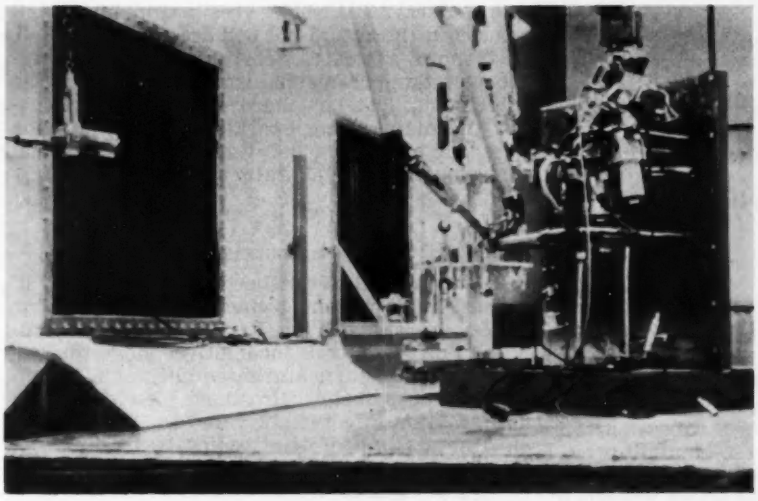

Fig. 7 — **Test car** carrying electro-hydraulic yaw damper mechanism positioned in hot cell mockup.

The lower level of the operations building provides space for the emergency power diesel-electric generating equipment, air conditioning equipment, and special services required for the test assemblies, such as, compressed air, electrical power of various voltages and frequencies, and hydraulic fluid.

A large stainless steel tank for liquid radioactive waste is located near the reactor building, and is connected to waste disposal seepage basins nearby.

Cooling towers for the primary cooling system and the air conditioning system are also located near the reactor building.

Radiation Effects Laboratory

In the Radiation Effects Laboratory (Fig. 3) aircraft parts and assemblies are prepared for irradiation, instrumented, and given pre-irradiation tests. It is here also that post-irradiation tests are performed, and detailed analyses completed to determine the extent of activation or damage caused by the irradiation.

The floor plan of the Radiation Effects Laboratory (Fig. 4) indicates that there are four main working areas in the building. This subdivision is necessary to assure adequate protection for laboratory personnel responsible for handling radioactive materials.

The entrance to the building leads into an office area where studies and reports are prepared. Passage through a change room allows access to the warm laboratories, where experiments and analytical work can be performed on slightly radioactive material, or to the hot cell complex, where tests and experiments are performed on highly activated parts and assemblies.

The test sequence on an aircraft subsystem begins when the test article is received from the factory. It is first delivered to the test article assembly area, where it is mounted on a test car. This mounting must be carefully engineered to permit operation

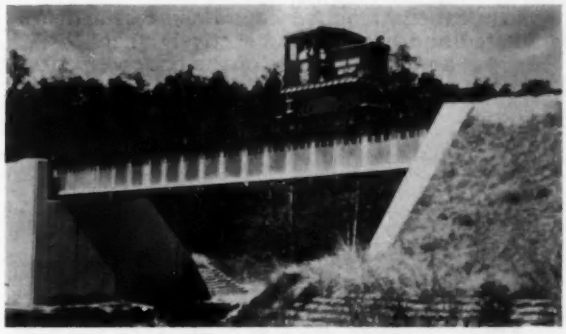

Fig. 8 — **Locomotive** of Hot Materials Transport System crossing trestle above Etowah River.

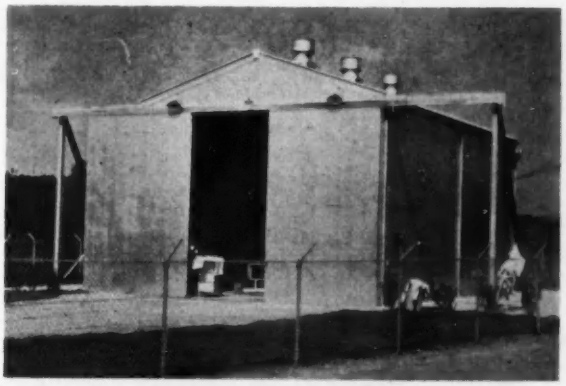

Fig. 9 — **Critical Experiment Facility** is sheet metal building housing small swimming pool in which critical experiment reactor is operated.

Lockheed's Georgia Nuclear Lab Will Accelerate ANP Program

. . . continued

of the subsystem in the same manner as it would operate in the aircraft. Instrumentation is also installed to permit measurement of each significant performance characteristic of the subsystem throughout the irradiation and post-irradiation tests. Finally, a disassembly check is made of the subsystem to make sure that it can be taken apart piece by piece using remote manipulator equipment.

The disassembly check is performed in a mockup of an actual hot cell, as illustrated in Fig. 5. The use of this mockup to check the test article prior to irradiation permits the engineers responsible for the testing program to make any needed adjustments or modifications required before the test article is irradiated and becomes radioactively "hot."

Fig. 6 is an exterior photo of the hot cell mockup. Controls for the Argonne Model 8 type manipulators and the General Mills bridge type manipulator such as are used in the actual hot cell are shown.

Fig. 7 shows a test car carrying an electro-hydraulic yaw damper mechanism positioned in the hot cell mockup. The mechanism is being disassembled by the manipulator operator stationed on the opposite side of the hot cell wall and using special tools developed in the laboratory.

Hot Materials Transport System

The Hot Materials Transport System consists of a standard-gage railroad connecting the Radiation Effects Laboratory with the Radiation Effects Facility. Small diesel-electric locomotives move the test cars, carrying the parts and assemblies to be irradiated. The tracks of the railroad are seen at the rear of the Radiation Effects Laboratory in Fig. 3.

Fig. 8 shows one of the locomotives crossing a trestle above the Etowah River.

Critical Experiment Facility

The Critical Experiment Facility (Fig. 9) is a sheet metal building that houses a small swimming pool in which a critical experiment reactor is operated.

Fig. 10 shows the critical experiment reactor structure. This reactor is an exact duplicate of the internal structural elements and control rod drive mechanisms of the Radiation Effects Reactor. It is used to experimentally build up and calibrate the cores that are destined for use in the Radiation Effects Reactor. When a core has been built up and calibrated in the critical experiment reactor, the fuel elements and control rods are removed and placed in shipping casks for movement to the Radiation Effects Reactor by truck. The calibrated core is reassembled in the Radiation Effects Reactor by placing each fuel element and control rod in the exact position as determined in the critical experiment reactor. This saves a great deal of time in the Radiation Effects Reactor refueling operation.

Nuclear Support Laboratory

The Nuclear Support Laboratory provides space for administrative and engineering offices, the meteorological headquarters, and a small cafeteria. In addition, there is a 10,000 sq ft area occupied by the Nuclear Measurements Laboratory. This laboratory is equipped and staffed to provide special nuclear instrumentation required for the operation and control of the reactor as well as for the aircraft parts and assemblies tested in the irradiation test program. Calibration and maintenance of all instrumentation are also performed here.

Other support facilities are located adjacent to the Nuclear Support Laboratory. These include a warehouse for materials and supplies; a general service building housing guard and fire headquarters and a garage for the motor pool; and a water plant supplying industrial and portable water for the entire laboratory complex.

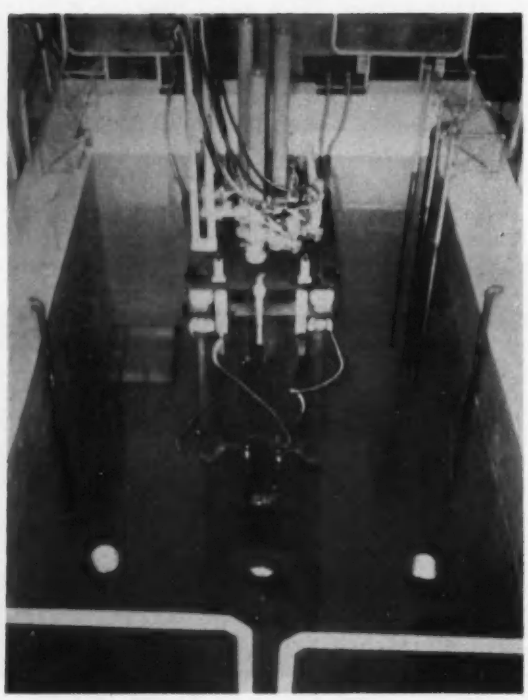

Fig. 10 — **Structure** of critical experiment reactor, which is located in a small swimming pool.

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How to Determine Compatibility of Seals and Fluids

Solubility parameter concept provides a good tool for screening rubberlike materials for compatibility with synthetic hydraulic fluids.

Based on paper by

E. A. Webster and R. G. Larkin

Douglas Aircraft Co.

THE solubility parameter concept is simpler than the similarity rule and it meets most of the requirements for convenient, semiquantitative predictions, since it provides a numerical index by which resistance as well as solubility can be predicted with reasonable accuracy.

The theory is thoroughly discussed by Hildebrand and Scott[1], who define the solubility parameter as the square root of the cohesive energy density. The latter has been defined by Scatchard[2] as the energy of vaporization per cubic centimeter of molecular volume of a liquid. Other references[3-6] discuss various applications.

Perhaps the best way to explain solubility parameters is in terms of liquid-liquid interaction. As with other thermodynamic processes for systems in equilibrium, these reactions follow the free-energy law, $\Delta F = \Delta H - T\Delta S$, where ΔF = free energy, ΔH = heat of mixing, T = temperature; and ΔS = entropy. This law predicts that a process will take place if ΔF is negative. From the equation it can be seen that one way to make ΔF negative would be to have the ΔH term smaller than the $T\Delta S$ term.

A consequence of the Hildebrand-Scott concept is that the heat of mixing (ΔH) is at a minimum when the solubility parameters of the two liquids are equal. Actually, it has been determined empirically that large interactions between fluids and elastomers are possible at 25 C if the solubility parameters are within 1.5 units or less of each other.

A second way of making ΔF negative and promoting mixing, swelling, or dissolving, is to increase the magnitude of the negative $T\Delta S$ term until it is larger than ΔH. This can be done by increasing the temperature, a common method of assisting in the solution of a material in a solvent.

Assumptions To Be Made

Several assumptions must be made in using this tool. First, the theory is concerned mainly with liquid-liquid interactions, therefore, we must consider polymers to be very viscous liquids. This assumption is valid when considering hydraulic system applications, since the rubber polymers in question

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[1] "Solubility of Nonelectrolytes," by J. H. Hildebrand and R. L. Scott. Pub. by Reinhold, N. Y., 1924, 1936, 1950.

[2] G. Scatchard, *Chemical Review*, Vol. 8, 1931.

[3] H. Burrell, *Interchemical Review*, Vol. 14, No. 1, 1955, pp. 3–16; No. 2, 1955, pp. 31–46.

[4] M. H. Witt, Monsanto Chemical Co., Organic Chemical Division Report, April 1, 1954.

[5] E. E. Walker, *Journal of Applied Chemistry*, Vol. 2, 1952, pp. 470–481.

[6] P. A. Small, Journal of Applied Chemistry, Vol. 3, 1953, pp. 71–80.

Table 1 — Derivation of Solubility Parameter

$$\delta \equiv \left(\frac{\Delta E}{V}\right)^{1/2}$$

BUT $\Delta E \equiv \Delta H - RT$

AND $V = \frac{M}{\rho}$

THEREFORE $\delta = \left[\frac{(\Delta H - RT)\rho}{M}\right]^{1/2}$

AT 25°C, T = 298°K R = 1.98

THEREFORE $\delta_{25} = \left[\frac{(\Delta H - 590)\rho}{M}\right]^{1/2}$

ΔH, IF NOT AVAILABLE FOR THE LIQUID UNDER CONSIDERATION CAN BE ESTIMATED FROM BOILING POINT IN °K USING:

TROUTON'S RULE: $\Delta H \equiv 21T_b$

HILDEBRAND'S RULE: $\Delta H_{25} = 23.7T_b + 0.020T_b^2 - 2950$

$\delta \equiv$ SOLUBILITY PARAMETER $(cal/cc)^{1/2}$

$\Delta E \equiv$ MOLAR ENERGY OF VAPORIZATION (cal/mol)

$V \equiv$ MOLAR VOLUME OF LIQUID (CC)

$\Delta H \equiv$ MOLAR HEAT OF VAPORIZATION (cal/mol)

$R \equiv$ UNIVERSAL GAS CONSTANT = 1.98

$T \equiv$ ABSOLUTE TEMPERATURE (°K)

$M \equiv$ MOLECULAR WEIGHT (GRAMS)

$\rho \equiv$ DENSITY (GRAMS/CC)

$T_b \equiv$ BOILING POINT OF LIQUID (°K)

Table 2 — Compatibility of Elastomers with Fluids Based on Per Cent Swell

% Swell	Evaluation	Symbol: Observed	Symbol: Est.
0 - 15	Satisfactory	S	s
16 - 40	Doubtful	D	d
41 -	Unsatisfactory	U	u

Fluids	Polymer Type: Silicone	Butyl	Natural	Buna-S (GR-S)	Neoprenes	Hypalon	Kel-F-Elastomer	Thiokols FA & ST	Philprene VP	Buna-N (Low Nitrile)	Buna-N (High Nitrile)	Acrylates (Hycar 4021)	Viton A	LS-53	1F 4 (FBA)	Vyram
MIL-O-5606 (Hydrocarbon)	U	U	U	U	D	D	S	S	S	S	S	S	S	S	S	S
Engine Oil (Hydrocarbon)	U	U	U	U	D	D	S	S	S	S	S	S	S	S	S	S
OS-45 (Silicate)	U	U	U	D	S[1]	s	S	D[2]	d[2]	D[2]	D[2]	D[2]	S	U[2]	S	D[2]
MLO-8200 (Silicate)	U	u	u	d	s[1]	s	S	d[2]	d[2]	d[2]	d[2]	d[2]	S	u[2]	s	d[2]
Fuel, Gasoline, JP-4 (Hydrocarbon, Naphthenics, & Aromatic)	U	U	U	U	U	U	S	S	D	D	S	S	S	S	S	S
MIL-L-7808 (Diester, Organic)	D	U	U	U	U	U	U	S	D	D	S	S	D	U[2]	S	S
Skydrol-7000 (Phosphate)	S	S	D	U	U	U	U	U[3]	U	U	U	U	u	S	S	S
Skydrol-500 (Phosphate)	S	S	D	U	U	U	U	U[3]	U	U	U	U	U	S	D	S
Pydraul (Phosphate + Additive)	S	S	d	u	u			D						S		S
Water	S	S	S	S	S	S	S	S		S	S	D[4]	s	S	D[4]	D[4]

[1] Types W, WRT, and WHV only.
[2] If used above 300 F.
[3] Thiokol PR-1, no longer available, was satisfactory.
[4] In hot water.

Note: Many factors affect per cent swell that are not reflected in the above tabulation. Consult manufacturer for accurate information on specific compounds.

are not used below their freezing or crystallization point.

Secondly, the solubility parameter is defined as the square root of the energy of vaporization per cc of molecular volume (see Table 1). Since rubber gums cannot be volatilized to measure the heat of vaporization without destroying them, an indirect method is used. This consists of immersing the polymer in a series of liquids of accurately known solubility parameters and noting in which the maximum swelling or complete solution occurs. Once established for a polymer, the solubility parameter can be used for predicting resistance to any liquid. Any convenient group of liquids of known solubility parameter can be used for this purpose, but if possible, liquids should be used which have similar viscosities and molecular volumes in order to minimize the effects of migration velocity within the polymer.

It must be emphasized that this procedure for polymers is more subject to error than a calculation from accurately measured liquid vaporization data. Moreover, several determinations with different sets of liquids may be needed to resolve discrepancies and completely characterize the polymer. A graph showing the position of several typical liquids and polymers on the solubility parameter scale is shown in Fig. 1. For immunity to swelling, the parameters should be as far apart as possible, at least 1.5 units for most combinations at room temperature, and 3.0 or more at higher temperatures.

What the Concept Tells

Many familiar empirical facts are clear in the light of this concept. For example, it can be seen why natural rubber is worthless with hydrocarbon oils, and why benzene and toluene are popular solvents for natural rubber cement. Neoprene has a higher solubility parameter than natural rubber and is much more resistant to hydrocarbon oils.

The nitrile rubbers now available have a solubility parameter high enough to exceed the 1.5 unit difference criterion required for resistance to most hydrocarbons. This explains why they are the most common elastomers used with fuels (under MIL-P-5315) and with hydrocarbon hydraulic oils (under MIL-P-5516), engine oils, and others. By the same concept it is also clear why the best and most compatible plasticizers for neoprene and nitrile elastomers fall among the organic or phosphate esters. Two typical phosphates (Skydrol-7000 and Skydrol-500) are quite close to neoprene and nitrile rubbers on the solubility parameter scale.

Which Rubber Is Best

Because of their positions, butyl or silicone rubber would be an excellent choice for use with phosphate ester fluids. Going the opposite way on the scale from these fluids, Vyram could be used equally well because of its high solubility parameter. It is even more distant in solubility parameter from the hydrocarbon oils and fuels and, therefore, is immune to them also.

Laboratory tests results for these and other polymers are shown on Table 2.

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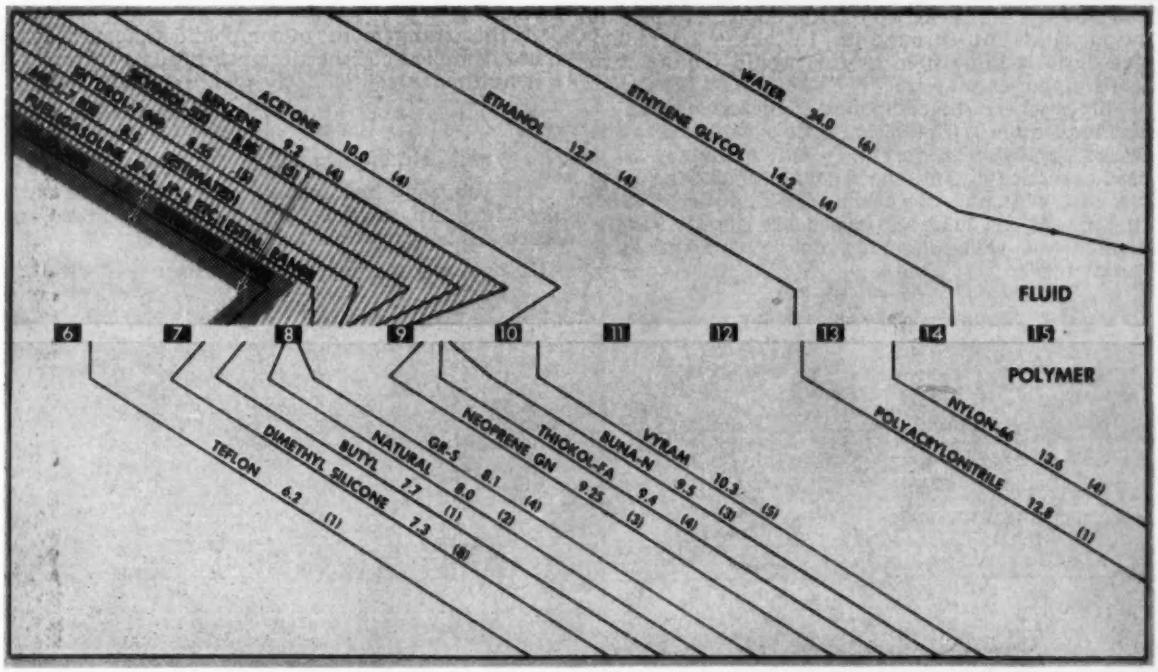


Fig. 1 — Positions of several typical liquids and polymers on the solubility parameter scale

Tips on Transmission Planetary

Based on L. Ray Buckendale Lecture by

Oliver K. Kelley
Buick Motor Division, GMC

COMPACT design, efficient gear and bearing design, easily "quieted," and good power shifting characteristics have made the planetary gear train the first choice for automatic transmissions. To take advantage of these qualities, the designer must choose from a wide variety of compounding systems and solve special gear and bearing problems.

selecting the gear reduction

A single simple planetary gear system will supply reduction gear ratios between 1.35/1 and 1.55/1 when the ring gear is driving and the sun gear is the reaction member. Ratios of 2.8/1 and better are possible when the sun gear is driving and the ring gear is the reaction member. These reduction ranges are limited because the pinions (planets) get too small, the ring gear runs into oversize problems, or the sun gear isn't large enough to let the output shaft run through it. In fact, a 2/1 reduction ratio is impossible as this would require zero pitch diameter pinions.

This is where the compound planetaries come in. The impossible 2/1 reduction ratio is achieved in the two examples shown in Fig. 1. One planetary-set is used to reduce the full-speed gear action of the other set, thus reducing the other set's final drive ratio. In Fig. 1A, the load and speed are almost equally divided and each planetary does about the same work.

Another arrangement (Fig. 1B) has the left-side ring-gear-input planetary driving the right-side planet carrier at a reduction ratio of 1.5/1. The planet pinions of the right-side carrier delivers its torque in two ways. The portion going to the output ring gear is 0.666 and the remaining 0.333 is delivered back to the original input shaft to artificially increase the input torque. Both of these designs are useful. Fig. 1A is a good way to get two different reduction ratios by using the first ring gear or the first carrier as the reaction member. Fig. 1B gives a single reduction ratio and an approximately equal reverse ratio by using either the first sun gear or the carrier combination as the reaction member.

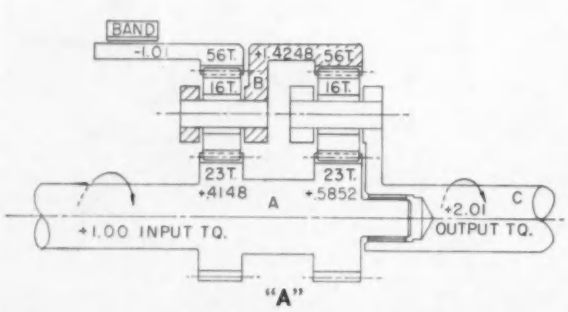
A third common arrangement used to get near 2/1 ratios is the Ravigneaux design shown in Fig. 2. In this design, there are two sun gears, three long pinions, three short pinions, and a ring gear which is used for reverse action. The planet carrier is the output member. There are structural advantages in this arrangement because of the single carrier. In the example shown, both forward and reverse ratios are 1.82/1. Also, this design is one of the better ways of keeping pitch line velocities down, thus reducing noise.

As the arrangements of compound systems become more complicated, the designer needs two tools to tell him quickly:

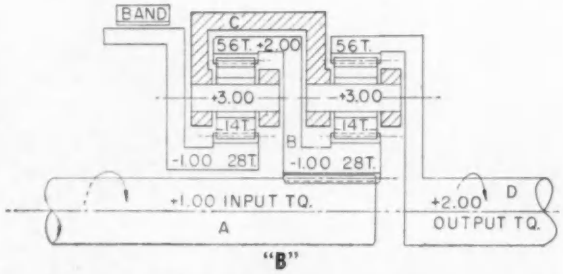
- The reduction ratios available from a given design.
- Whether the parts will go together.

The following four-step process will solve the first problem. An example for the load-dividing and Ravigneaux systems is shown in Fig. 3.

1. Hold any member of a gear train and turn an-



"A"



"B"

Fig. 1 — Two to one reduction ratio is impossible with a simple planetary gear arrangement. The two compounding arrangements shown overcome this problem. Both have an overall ratio of two to one. The "A" system is designed to divide the work equally between the two planetary sets. The "B" train is regenerative. A third of the output torque is fed back to the input shaft to artificially increase the torque.

Gear Design

other member one turn. Record the speed for each rotating member of the gear train when the speed of the member you are holding is zero. (Note: The calculation is easier if the initial member held is common to each gearset in the train.) The resulting figures disclose the speeds of all the members of the gear train.

2. Choose any of the rotating members for the next possible stationary member and add an equal quantity of opposite sign to its speed value. This makes its speed value zero. Then, add this same quantity to all the other members' speed value. This gives the original arrangement's zero members a definite speed value and changes all the other members' speed values all over.

3. Repeat this procedure until every member has been equated to zero, while the other members have changed their speeds to corresponding new values.

4. Now examine the potential speed relations of the compound gear train for usable forward and reverse ratios. The full potential of the gear train is revealed quickly by this simple algebraic addition method.

meshing the gears

Typical practice today is to have three, four, or six pinions in a planetary set. The pinions will not fit at all if the sum of the number of teeth in the sun and ring gears is odd and standard tooth proportions

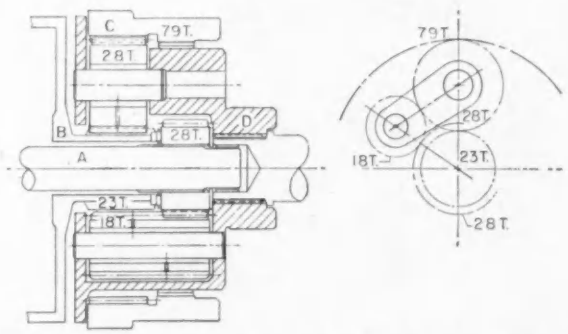
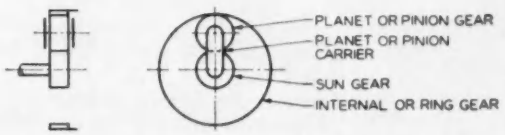


Fig. 2 — Ravigneaux compounding system achieves near 2/1 speed reduction and still uses a single pinion carrier. Three long and three short pinions are used to contact the two sun gears. The same tooth load prevails throughout the train. This design keeps the pitch line velocities down, which is one of the main reasons planetary gearing can effectively reduce noise.

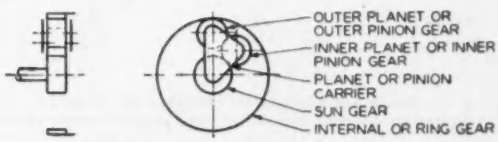
The following

planetary gear terminology

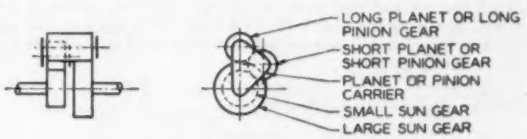
has been developed by the SAE Transmission Committee and appears in the 1959 SAE Handbook.



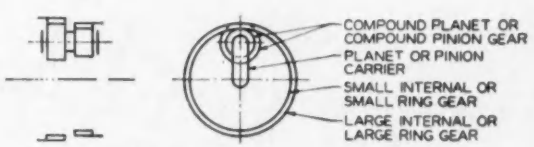
SIMPLE PLANETARY ARRANGEMENT


OUTER PLANET OR OUTER PINION GEAR
INNER PLANET OR INNER PINION GEAR
PLANET OR PINION CARRIER
SUN GEAR
INTERNAL OR RING GEAR

DUAL PINION OR DUAL PLANETARY ARRANGEMENT



EXTERNAL PLANETARY ARRANGEMENT

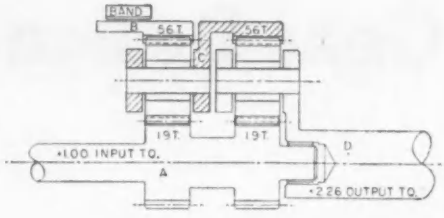

COMPOUND PLANET OR COMPOUND PINION GEAR
PLANET OR PINION CARRIER
SMALL INTERNAL OR SMALL RING GEAR
LARGE INTERNAL OR LARGE RING GEAR

COMPOUND PLANET OR COMPOUND PINION PLANETARY ARRANGEMENT

STEP 4

	A	B	C	D	REDUCTION RATIOS FORWARD	REVERSE
STEP 1	+1.00	$-.3393 \times \frac{12}{56}$	0	$+.2533 \times \frac{19}{19}$	$\frac{A}{D}$ = 3.947 TO 1	$\frac{A}{B}$ = 2.947 TO 1
	-.2533	-.2533	-.2533	-.2533		$\frac{B}{D}$ = 1.34 TO 1
STEP 2	+.7467	-.5920	-.2533	0	$\frac{B}{C}$ = 2.337 TO 1	$\frac{A}{B}$ = 1.261 TO 1
	+.5920	+.5920	+.5920	+.5920		$\frac{A}{C}$ = 2.947 TO 1
STEP 3	+1.3387	0	+.3387	+.5920	$\frac{A}{C}$ = 3.947 TO 1	
	-1.3387	-1.3387	-1.3387	-1.3387	$\frac{A}{B}$ = 2.26 TO 1	
					$\frac{D}{C}$ = 1.747 TO 1	
STEP 3a	0	-1.3387	-1.00	-.7467	$\frac{B}{C}$ = 1.3387 TO 1	
					$\frac{C}{D}$ = 1.3387 TO 1	
					$\frac{B}{D}$ = 1.793 TO 1	

OBVIOUSLY WE WOULD HAVE TWELVE OVERDRIVE RATIOS BY TAKING THE RECIPROCAL OF THE ABOVE RATIOS



STEP 4

	A	B	C	D	REDUCTION RATIOS FORWARD	REVERSE
STEP 1	+1.00	$-1.2174 \times \frac{28}{23}$	$+.3544 \times \frac{28}{79}$	0	$\frac{A}{C}$ = 2.821 TO 1	$\frac{B}{C}$ 3.435 TO 1
	-.3544	-.3544	-.3544	-.3544		$\frac{B}{A}$ = 1.2174 TO 1
STEP 2	+.6456	-1.5718	0	-.3544	$\frac{B}{D}$ = 4.435 TO 1	$\frac{B}{A}$ = 2.434 TO 1
	+1.5718	+1.5718	+1.5718	+1.5718		$\frac{A}{D}$ 1.821 TO 1
STEP 3	+2.2174	0	+1.5718	+1.2174	$\frac{A}{C}$ = 1.410 TO 1	
	-2.2174	-2.2174	-2.2174	-2.2174	$\frac{A}{D}$ = 1.821 TO 1	
					$\frac{C}{D}$ = 1.291 TO 1	
STEP 3a	0	-2.2174	-.6456	-1.00	$\frac{B}{C}$ = 3.435 TO 1	
					$\frac{B}{D}$ = 2.2174 TO 1	
					$\frac{D}{C}$ = 1.549 TO 1	

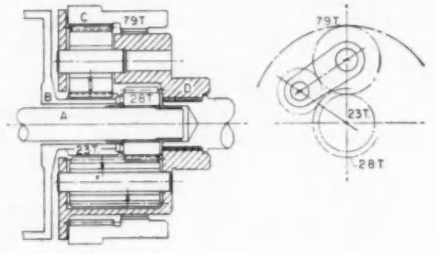
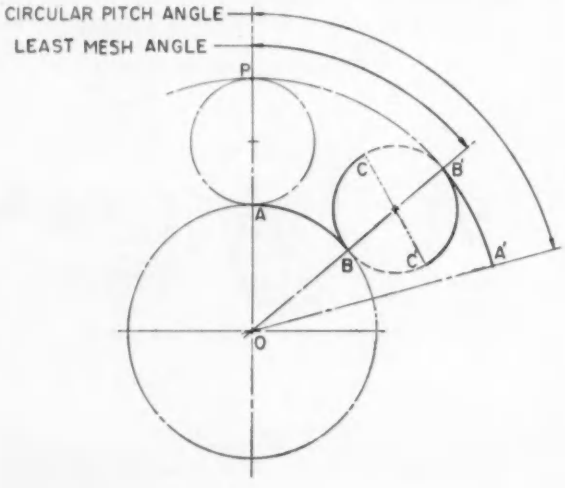
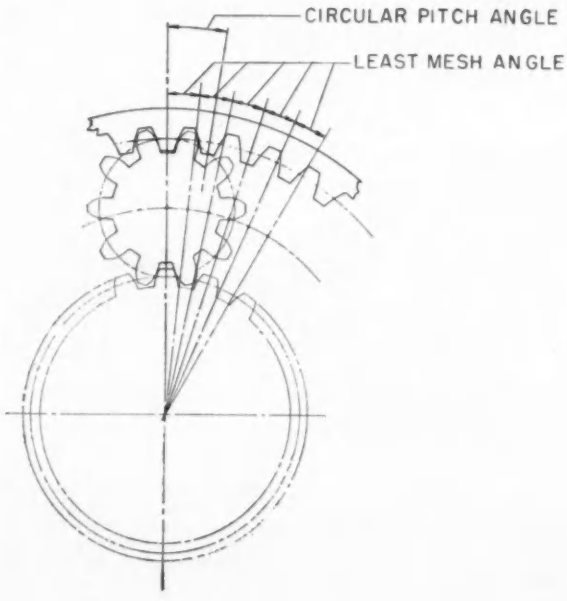


Fig. 3 — Simple add-and-subtract technique can be used to rapidly find all the reduction ratios in a complex compound planetary system. The ratio is figured for one condition and all other possibilities immediately follow. The load-dividing and Ravigneaux trains are shown.

Fig. 4 — Calculating the number of positions where a pinion will fit between the sun and ring gears of a simple planetary system is accomplished by finding the LEAST MESH ANGLE. This angle can be used to check if the gears will go together. It is also used to see if the pinions can be evenly spaced.





Tips on Transmission Planetary Gear Design

. . . continued

are used. In addition, the spacing of the pinions should be even. The meshing requirements can be examined by calculating the "least mesh angle."

For example, the number of places that the pinion will mesh in a simple planetary system is equal to the sum of the number of teeth in the sun and ring gears. The least mesh angle, therefore, is 360/(sun plus ring gear teeth). Fig. 4 shows how this is calculated.

A single pinion is meshed with the sun and ring gear. The smallest angle between meshing positions is found by lifting the pinion out of mesh with the ring gear and rotating it around the sun gear until it meshes again with the ring gear. Since the planet teeth turn about the center of the planet pinion, the size of the least mesh angle is affected by the direction of rotation of the planet as the carrier is turned around the sun gear. One way to analyze this problem is to rotate the ring gear one tooth (one circular pitch) and calculate the "least mesh angle" from the distance the carrier travels during this operation. When this technique is used, the following derivation holds: (S and R are the number of teeth in the sun and ring gears)

$$\angle POA' = \frac{360}{R}$$

$$\angle AOB + \angle A'OB' = \angle POA'$$

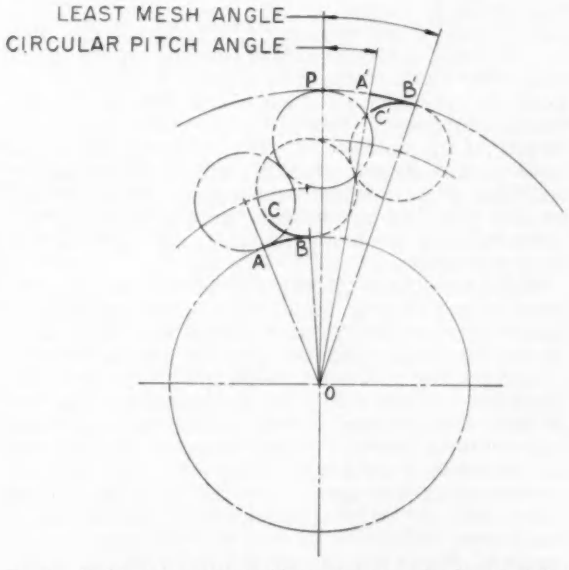


Fig. 5 — Double pinion gear set follows the same rules for calculating the least mesh angle, as the simple planetary system. However, the LEAST MESH ANGLE in this case will be less than the circular pitch of the ring gear since the least mesh angle is defined as the smallest angle traversed before reengagement when the pinions are disengaged from the ring gear and rotated around the sun gear.

but:

$$\angle A'OB' = \angle AOB\left(\frac{S}{R}\right) \text{ since } A'B' = AB$$

$$\angle AOB + \angle AOB\left(\frac{S}{R}\right) = \angle POA' = \frac{360}{R}$$

$$\angle AOB\left(1 + \frac{S}{R}\right) = \frac{360}{R}$$

$$\angle AOB = \left(\frac{R+S}{R}\right) = \frac{360}{R}$$

$$\angle AOB = \frac{360}{R+S}$$

To have evenly spaced pinions, the angle between them must be $360/N$, where N is the number of pinions. This angle must be an integral multiple of the least mesh angle,
or:

$$\frac{360/N}{360/(R+S)} = \text{whole number}$$

or:

$$\frac{R+S}{N} = \text{whole number} = K$$

For the double pinion set shown in Fig. 5, the least mesh angle is found as follows:

$$\angle AOB = \angle POB'$$

$$\angle POA' = \frac{360}{R}$$

$$\angle POA' = \angle POB' - \angle A'OB'$$

$$\frac{360}{R} = \angle AOB - \angle AOB\left(\frac{S}{R}\right)$$

$$\angle A'OB' = \angle AOB\left(\frac{S}{R}\right)$$

$$\frac{360}{R} = \angle AOB\left(\frac{R-S}{R}\right)$$

$$\angle AOB = \frac{360}{R-S}$$

and for evenly spaced pinions:

$$K = \frac{R-S}{N}$$

The spacing for long and short pinions meshing with two sun gears (as illustrated in Fig. 6) is found by:

$$\angle POA' = \frac{360}{S_1} = \angle POB' + \angle A'OB'$$

but:

$$\angle POB' = \angle AOB$$

and:

$$\angle A'OB' = \angle AOB\left(\frac{S_2}{S_1}\right)$$

therefore:

$$\frac{360}{S_1} = \angle AOB + \angle AOB\left(\frac{S_2}{S_1}\right) = \angle AOB\left(\frac{S_1+S_2}{S_1}\right)$$

$$\angle AOB = \frac{360}{S_1+S_2}$$

and:

$$K = \frac{S_1-S_2}{N}$$

An example of the use of this technique is the

Tips on Transmission Planetary Gear Design

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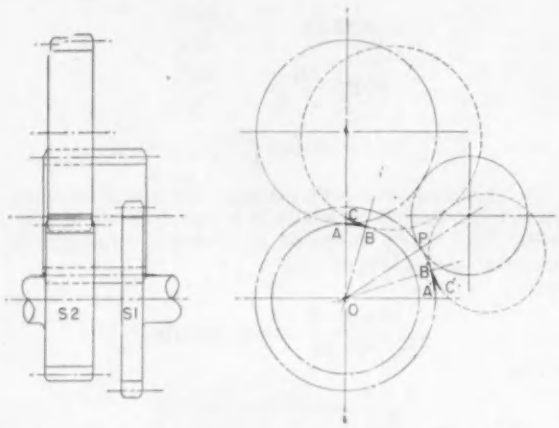


Fig. 6 — In the case of a long and short pinion meshing with two sun gears, the LEAST MESH ANGLE is calculated on the smaller sun gear and the larger sun gear takes the place of the ring gear.

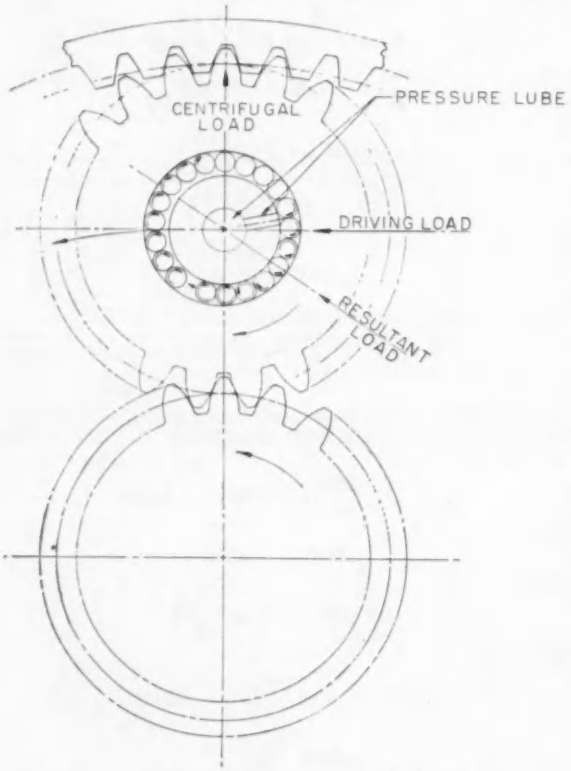


Fig. 7 — Centrifugal loads on the pinion needle bearing cause the needles to bunch up. The needles rub against each other, losing rotational speed. When they are forced to the load-carrying part of the bearing, they undergo high rotational accelerations, which cause wear. This problem is usually found in the heavy-duty high-speed transmissions.

Ravigneaux gear set in the Buick Dynaflow transmission. The number of teeth in the gears are:

Ring gear $(R) = 79$
Front sun gear $(S_1) = 23$
Rear sun gear $(S_2) = 28$

The front gears form a simple planetary set and

$$K = \frac{R + S_1}{N} = \frac{79 + 23}{3} = 37$$

The rear sun gear, the two pinions, and the ring gear are a double pinion gear set. In this case:

$$K = \frac{R - S_2}{N} = \frac{79 - 28}{3} = 17$$

The two sun gears and the pinions are another gearset which must be considered:

$$K = \frac{S_1 + S_2}{N} = \frac{23 + 28}{3} = 17$$

All these combinations result in whole numbers which means the transmission will assemble and the pinions are equally spaced. Without such check, it is difficult to determine if an interference exists.

bearing design

The pinion gears present a bearing design problem in a simple planetary system as the sun and ring gears do not carry a driving load. The pinion gears usually use needle bearings to transmit their load to the pinion carrier. These needles must resist destructive end-thrust and centrifugal forces.

The relatively flexible long bearing needle tries to roll on a reflected-at-the-middle shaft and also on the inner surface of a rigid pinion bore. This does not give true rolling action. Also, the high helix angle thrust loads, especially in the larger size pinions, imposes a sizable cocking couple on the bearing. This shifts the load to a spiral pattern on the sides of the deflected shaft. The resultant spiral rolling pattern can produce destructively high end thrust on the needles. To cope with this problem, industry has gone to an end thrust washer that itself has small needle bearings mounted in the washer. The washer has its short needle bearings caged radially to absorb the end thrust loads of the pinion bearings.

High centrifugal forces in planet carriers can cause severe rubbing action between the needles in the pinion bearing. Fig. 7 shows that this force makes the needles bunch together during the unloaded portion of their trip around the races. The resultant rubbing action causes each needle to lose its own private rpm. When the needle is finally forced into a position where it again takes up the driving load, it must accelerate instantaneously to its correct private rpm. This action is much like that of the wheels of an airplane at the moment of touchdown. There is no clearcut solution for this problem. However, in the past, the use of caged needles and extreme lubrication have alleviated the problem.

To Order SP-134 . . .
. . . on which this article is based, turn to page 6.

Mockups Save Money on Ground Support Equipment

Based on paper by

Willard H. Pitt

United Air Lines, Inc.

EACH major airline will spend about $5½ million for the ground support equipment required to satisfy its present jet fleet commitments. Only a very small percentage of this equipment can be so called off-the-shelf stock items from a manufacturer. The remaining much larger percentage falls generally into two categories.

- Items that are manufactured in accordance with a specification prepared by the airline and which usually call out functional requirements.
- Items that are to be manufactured from complete working drawings covering a detailed design conceived and developed by the airline.

In the development of ground items one of the more difficult areas facing the engineer is the initial determination of functional requirements and then their reduction to practical limits or values. Using a passenger stand as an example — how wide should the stairway be? How big should the top platform be? Should it be powered and, if so, how fast should it go? What should the structural safety factor be?

There are many people in the act. The passenger service man would like a very spacious stand, easily controlled, that does everything for the convenience and protection of the passenger. The publicity man wants wide stairs with a top platform capable of handling at least one football team. At the same time, the stand must be photogenic and striking in its eye appeal. From the maintenance man's viewpoint, the stand should be small, simple, with no mechanical complication to cause trouble. Management, of course, feels the stand should cost very little. If the user is lukewarm on the design, there is a good chance that the unit will never give satisfactory service, and will, at a later date have to be replaced with something else. It's amazing how much trouble can be experienced with an unloved mechanical device.

That's the reason that rarely do two airlines purchase the same piece of ground equipment in the standard form presented by the manufacturer. The item invariably requires numerous changes from the article which had previously been sold to another airline before it is deemed acceptable. These changes tend to bewilder and frustrate some manufacturers, who see the unit doing the same job on both airlines. Nevertheless these changes must be made to gain user acceptance of the unit.

There are also more tangible differences in requirements such as different environmental conditions, or different operating policies, different viewpoints on safety aspects, and many other situations inherent to individual airlines.

A third difficult area in the functional requirement picture stems from the fact that, frequently, the people in the using department are not mechanically minded, and when requirements are spelled out affecting such things as size and capacity, it is done without realizing just what the end product would be, how it would operate, or what it would look like. This can, if not carefully controlled, result in this same man later saying something like, "I didn't think it would be that big, or that it would look like that. It isn't what I had envisioned. I can see a lot of problems in trying to use it!"

This problem can be effectively handled through the use of inexpensive mockups, or, where practical, development and manufacture of a prototype unit.

The DC-8 passenger stand is a case in point. A wooden mockup was made of the stairway and top platform. This mockup resulted in reducing both the width of the steps and size of the upper platform, from that originally specified from the using department. The mockup was made smaller than originally specified by the user and the prototype was reduced further after actually seeing how big was "big."

The mockup process has been used quite effectively in other areas such as cargo containers, special work stands, buffets, and other items of this type.

To Order Paper No. 18R . . .
. . . on which this article is based, turn to page 6.

Here's what's needed to supply Clean Fuel

Based on report by

G. T. Coker
Shell Oil Co., and

R. G. Davis
Shell Oil Co. of Canada

THE problem of jet fuel cleanliness must be attacked by the oil industry, fuel handling people, and airline operators if clean fuel is to be delivered economically. The problem breaks down into three parts.

- **How clean must the fuel be?**
- **How is cleanliness measured?**
- **How can fuel cleanliness be controlled?**

What do the engines require?

It does not appear possible to assign an absolute number for the degree of fuel cleanliness because of three reasons.

The first is the fact that the same engine will react differently to various types of fuels such as JP-4 and kerosene. Service experience in RAF planes shows that fuel pumps can tolerate more contaminant when using kerosene than when using JP-4. This was again confirmed in the laboratory of the engine manufacturer when the wear rig test showed a 2/1 load carrying advantage for kerosene over JP-4.

Second, is the effect of various sources of contamination related to aircraft operation such as: airborne dust entering fuel system vents and breather orifices, dirt introduced at overhaul — including the fine dust often associated with the new "bag type" aircraft fuel cells, fuel system corrosion products, and fuel system wear or fret corrosion products.

Third, is the possible difference in contamination tolerance between various makes of engines. For example, it is conceivable that a particular engine fuel system might fail only through erosion-type wear. In such a case, the total amount of inorganic contamination would be of prime importance. At the other end of the scale, another engine system might fail through random sticking and clogging of close-tolerance valves and controls. In this case, the number and size of large particles found in the fuel would be of prime importance.

These factors lead to the conclusion that the method of reporting fuel cleanliness must be more sophisticated than a simple "total weight" method.

How to measure fuel cleanliness

Two factors are of importance in measuring fuel cleanliness. The measurement must have significance in terms of the engine, and it must be readily reproducible.

Knowing the size distribution of particles gives more useful information than just having the total

Table 1 — Example of Particle Distribution

Size Range, microns	Particles, number/ml	
	Sample A	Sample B
3-5	5.1	261
5-10	3.9	154
10-20	2.4	123
20-30	0.5	16.2
30-50	0.2	11.1
50-100	0.3	7.2
over 100	0.1	1.1
Total	12.5	573.6
mg/l	0.3	0.9

Knowing the distribution of particle size in a fuel gives useful information about potential engine damage when examined with the weight of contaminant.

for Turbine Transports

number of weight of contaminants. An example is the analysis of two samples shown in Table 1. It suggests that results be reported on weight, particle count, and size distribution *and* the extent of large particles.

When using a millipore membrane to measure the contamination of a fuel, the results can be misleading if "total insoluables" are reported. The amount of inorganic insolubles, such as iron and silica, obtained by ashing the filter is a much more reproducible figure. (See Table 2.) This value and the particle size distribution seem to be a better index of fuel cleanliness than the "total insolubles."

How to control quality

To guarantee that clean fuel will be put aboard an airplane requires two types of equipment or handling. A system must be set up that will normally supply clean fuel to the airplane and a fail-safe mechanism must stop the flow of fuel into the airplane if any contaminant or moisture is present. This technique can guarantee clean fuel to the aircraft.

The system now used to supply clean fuel is a combination of natural settling in tanks and filter-separators. Such equipment and handling should start at the terminal storage tanks of the oil company and continue right up to delivery to the airplane. Only in this way can a sure and economical cleaning process go on. For example, if all the natural settling is done at airport storage tanks, then local climate conditions may impose an undue hardship. This happened at Frobisher Bay, Canada, which is an increasingly important refueling station for international flights. An 80,000-bbl tank reached and remained at -14 F. At this temperature, the settling of a 10-micron rust particle in kerosene is about one-quarter the rate at 60 F.

Much of the present filtering equipment on the market is not adequate to meet present-day requirements, including equipment qualified under MIL-F-8508A. Cases exist where water is not completely removed and 50-micron particles are readily passed. Much more work must be done by filter companies before standard equipment can be adopted.

As far as fail-safe devices are concerned, considerable progress has been made. Shell, in conjunction with Streamline Filters, Ltd., has developed a fail-safe valve for the detection of free water. This new fuel monitor comprises a valve and sensing element, the latter being so constructed that it will cause the main valve to close when fuel containing free water passes through it. The valve opens and closes with the delivery valve so that there is little chance of it becoming frozen in the open position. Also, the delivery valve is automatically closed if the monitor valve has not been properly serviced and is not in an operating condition.

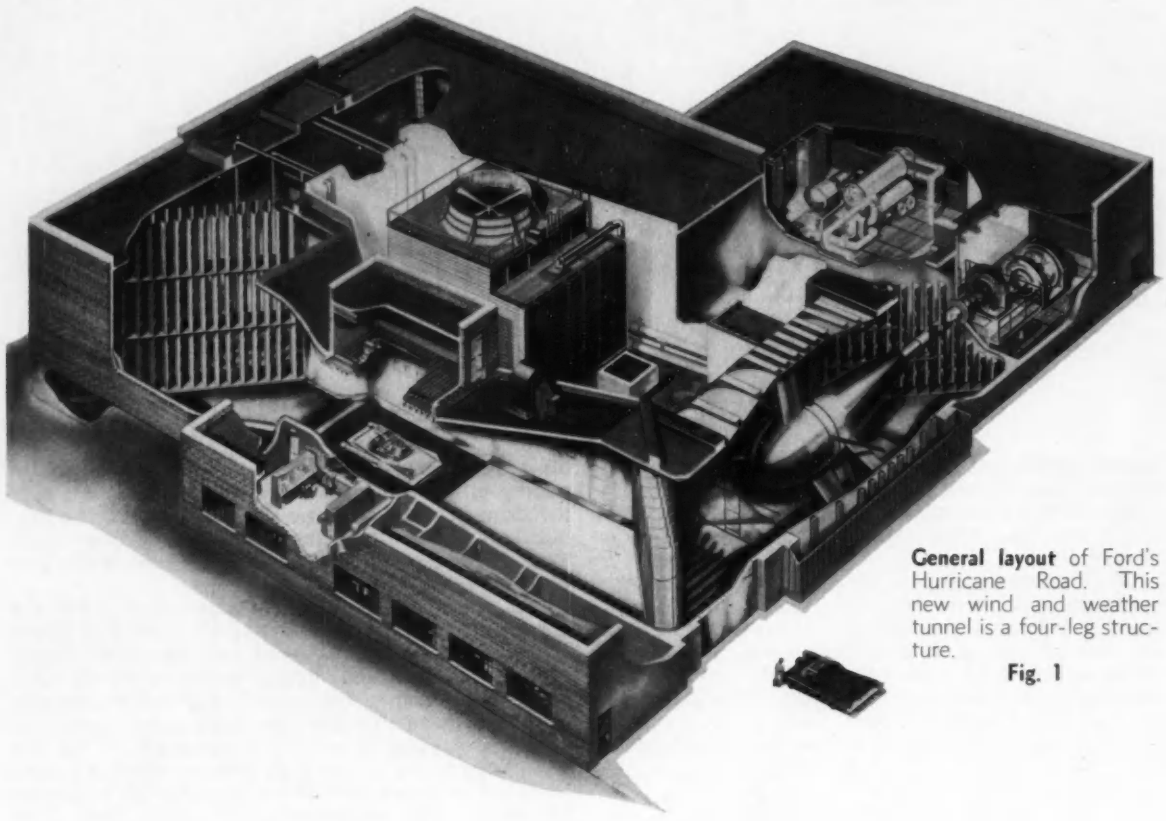
Corresponding fail-safe devices for particle filtration have not reached this stage, although the filtration industry is developing such equipment.

Spot checks on the cleanliness of fuel can be valuable in pinpointing the location of a heavy contaminating factor, when this situation occurs. However, they should not be a substitute for a fail-safe device.

Table 2 — Results of Ashing Insolubles (mg/Imp. gal)

Sample	Laboratory A		Laboratory B	
	Total Insolubles	Inorganic Insolubles	Total Insolubles	Inorganic Insolubles
1	0.0	0.0	2.1	0.0
2	0.0	0.0	2.4	0.1
3	–	0.0	1.9	0.0
4	–	0.1	6.6	0.4

Ashing the total insolubles gives a more accurate check between laboratories on particle contamination. Total-insolubles figures can be misleading because of possibility of forming variable amounts of insoluble organic residues on the millipore membrane during filtration and subsequent handling.



General layout of Ford's Hurricane Road. This new wind and weather tunnel is a four-leg structure.

Fig. 1

Hurricane Road—Ford's Wind and Weather Tunnel

Based on paper by

William A. McConnell

Ford Motor Co.

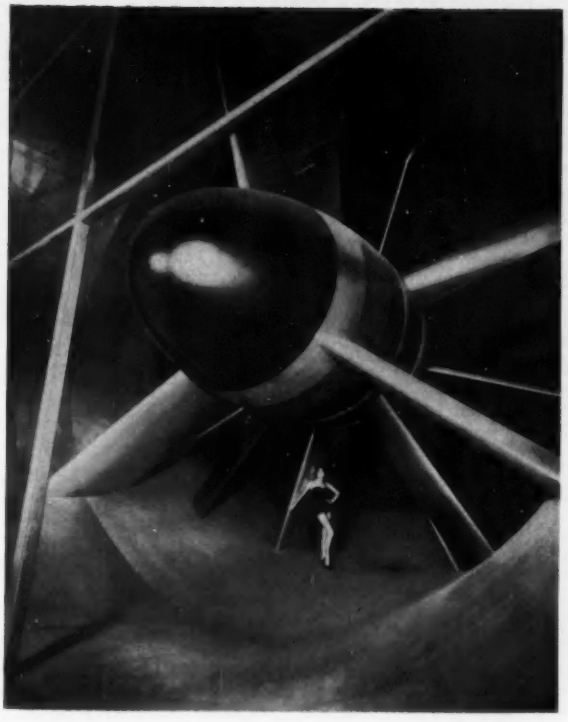
HURRICANE ROAD, Ford's new facility for indoor climatic testing, features precise control of weather variables and fast, accurate handling of data.

The four-leg design of this facility is shown in Fig. 1. In the first leg, adjacent to the control room is the test throat with a 250 sq ft cross-section, 20 ft wide and 12.5 ft high. Overhead are sun lamps set flush with the ceiling, and underneath are the dynamometer rolls. Immediately downstream is a make-up air blower in the roof, and dampers in the wall to maintain atmospheric pressure inside. The first set of turning vanes swing aside to admit vehicles for test.

The main circulation fan is located in the second leg. This location affords the most compact tunnel layout, with the least surface and volume to the air circuit. The air circulation fan is shown in Fig. 2.

In the third leg, the passage expands and air is slowed to no more than 35 mph, entering the fourth leg at low speed to provide good heat transfer and low loss through the full flow cooling coils. After the last set of turning vanes, the air enters the nozzle where the velocity increases about four times to a maximum of 140 mph through the test section.

A cooling tower for the refrigeration system water supply is located within a courtyard formed by the four legs of the tunnel. Refrigeration machinery,



Air circulation fan has five blades. It is 24 ft in diameter, delivers 3,000,000 cfm against a 3.8-in. head at full speed. Blades are laminated wood and fiber glass with a protective rubber coating. It can reach top air speed from standstill in about 20 sec.

Fig. 2

the fan drive motor, circulating pumps and electrical switch gear are housed in a room on the opposite side of the tunnel from the control room.

Adjacent to the second, or fan leg of the tunnel, is a preparation garage, where test vehicles are instrumented and readied in advance, to minimize down-time of the tunnel.

features of control room

From a console in the control room, the operator can start and control all tunnel machinery. At his fingertips are set-point controllers, with analog displays, to establish desired test conditions or independent variables such as air temperature, speed, humidity, road speed and load, sun, and rain. Digital displays are used for dependent variables or test data he might want to monitor or observe, including temperatures, torques and speeds of the engine or other components, outputs of various flow transducers for fuel, air, water, and miscellaneous pressures. When conditions are set to suit test requirements, the operator can press a switch to initiate the recording of preselected variables. If he is too lazy or busy to do this, a second switch will initiate the log cycle automatically at preselected time intervals.

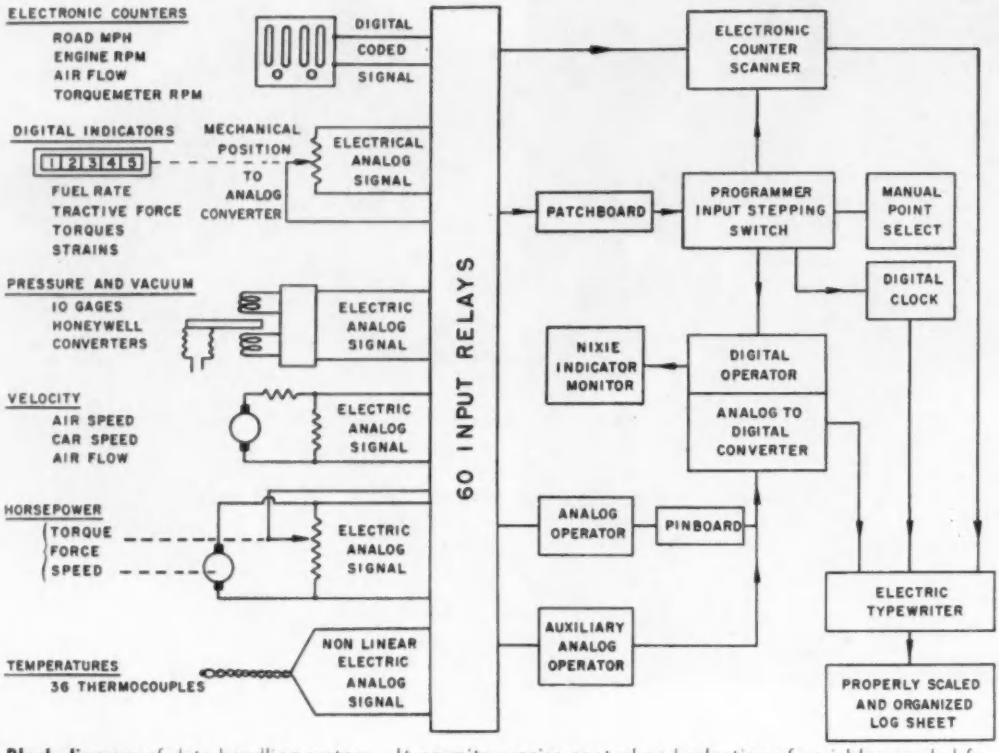
data handling system

The data logging console receives test information from about 60 transducers of various types. These inputs are converted into electrical analog signals, linearized where necessary, properly zero-suppressed if required, and then scaled to obtain a signal accurately proportioned to read in the desired measuring units. The sized voltage then is converted by a digital potentiometer into a pattern of contact closures which operate an electric typewriter. Fig. 3 shows a block diagram of the data handling system arrangement.

One novel feature of the logger is a patchboard selector panel. Any one of the 60 channels of information can be selected to appear in any column of the recording typewriter, by varying the scanning sequence. Only those data needed for a particular test need be logged.

Other features include: a point-select switch that permits monitoring any of the variables being logged, in the correct units, on a nixie light display; a decimal point switch that allows reading chosen variables to units or tenths of units (degrees, pound-feet, mph, or what have you) whichever degree of accuracy is significant; a digital clock to record time; and a system checking circuit, which reassures the operator of the equipment that everything is in order.

A pinboard within the console performs the functions basic to any computing machine. This part of the circuitry can be arranged to operate on one variable with another, calculate and print the result. The machine has been taught only to multiply torque and speed, divide by the proper constant, and



Block diagram of data handling system. It permits precise control and selection of variables needed for any particular test. The finished report is produced almost untouched by human hands.

Fig. 3

Ford's Wind and Weather Tunnel

. . . continued

print horsepower. It can also do a simple subtraction and a simple sum.

logging the data

The logger doesn't care what sequence it follows in scanning and printing data, so the preprinted log sheet form is arranged to suit convenience of the operator in setting test conditions, and needs of the data user in presenting end results. When the logger has finished its job, the operator types in the supplementary vehicle information or remarks, and the finished report is produced almost untouched by human hands.

A third panel is located in the control room to provide for the instruments which every equipment manufacturer thinks the operator will want to watch. Actually, the operator doesn't watch them, and they are entirely incidental to the main business of collecting test information. When any of these instruments exceeds operating limits, an alarm is sounded to alert the operator. If he takes no action, the equipment stops.

how hurricane road came to be

Three years ago a projection of the future work load indicated the need of a second wind tunnel, designed primarily for weather simulation and not for aerodynamic purposes. Past experience showed the need for higher velocity air streams, better velocity distribution, and lower blockage ratios. We also wanted more precise, automatic, temperature regulation, better humidity control, and reproduction of radiation heat loads. We required power absorption capacity to match current vehicles, with provisions for accurate simulation of transient conditions. And finally, we sought faster and more convenient means for setting test conditions and better methods of handling data.

With this new facility we can reproduce at will in Detroit the extremes of hot weather in Death Valley and the coldest weather at Bimidji, Minn. without waiting for nature to oblige.

To Order Paper No. 22S . . .
. . . on which this article is based, turn to page 6.

Putting Injection Benefits Into Carbureted Engines

Excerpts from paper by

D. E. Cooper, R. L. Courtney, and C. A. Hall

Ethyl Corp.

IMPROVED fuel and additive distribution through better carburetion can yield many of the benefits of fuel injection, recent Ethyl radioactive tracer tests of fuel distribution indicate. One segment of these studies, using a modified throttle in a particular 1956 V-8 truck engine, determined the effects of improved fuel and tel distribution on:

- Power.
- Fuel economy.
- Octane requirements.
- Tel effectiveness.

These effects were compared with the results obtained with a standard 2-barrel carburetor under constant-speed conditions only. These comparisons showed:

Power and fuel economy were increased with the modified throttle particularly at part throttle, where the greatest distribution improvements were effected. This is shown in Table 1. Here it appears that the maximum improvement was 6.9% at 2400 rpm and 3 in. of Hg manifold vacuum.

There was no improvement at wot or road load, since at these conditions distribution was good with both throttles.

Another indication of increased engine efficiency was reduction of the combustible material exhausted. Measurements showed that at between 2.5 and 5.5 in. of Hg manifold vacuum, at 2400 rpm, the combustibles exhausted were reduced from 7.1 to 5.1%. At manifold vacuums above 7 in. of Hg, there was no difference between carburetors. Others have observed similar effects with improved distribution.

The knocking tendency of the engine was increased with the "modified-throttle" carburetor at similar manifold vacuums. However, power was also increased and this allowed greater knock-limited power with fuels of the same octane number. At the condition of greatest improvement in fuel and tel distribution, 3 in. of Hg manifold vacuum (40 deg throttle), the knock-limited power was increased

Table 1 — Effect of Carburetor Throttle Type on Power and Fuel Economy

(Commercial fuel; max power ignition timing)

	1600 Rpm		2400 Rpm	
Manifold Vacuum, in. of Hg	3.0	5.8	3.0	5.8
Bhp[a]				
Standard Carburetor	56.7	51.4	84.9	76.8
Modified Throttle	59.7	52,6	91.2	80.3
Fuel Consumption, lb/hr				
Standard Carburetor	31.7	29.3	46.6	42.6
Modified Throttle	31.7	28.8	46.7	42.6
Brake Specific Fuel Consumption, lb/bph-hr				
Standard Carburetor	0.559	0.570	0.549	0.555
Modified Throttle	0.531	0.548	0.512	0.531
Decrease, %[b]	5.0	3.9	6.9	4.3

[a] Corrected to 60 F carburetor air temperature; 29.53 in. of Hg barometric pressure.
[b] With modified throttle.

Table 2 — Effect of Carburetor Throttle Type on Fuel Octane Rating

(2400 rpm; 3 in. of Hg manifold vacuum; 40 deg throttle)

Fuel	Tel ml/gal	Octane Rating		Change due to Modified Throttle
		Standard Carburetor	Modified Throttle	
RE100A	0	80.9	80.0	–0.9
	3	88.3	89.5	1.2
		7.4	9.5	2.1
630	0	84.4	81.4	–3.0
	3	88.7	89.8	1.1
		4.3	8.4	4.1
631	0	84.8	82.8	–2.0
	3	88.2	88.8	0.6
		3.4	6.0	2.6

Putting Injection Benefits Into Carbureted Engines

. . . continued

about 7.5% for fuel of a given octane number.

The effect of carburetor throttle type on the octane ratings of both clear and leaded fuels is of interest. Table 2 summarizes the ratings for three fuels measured at 40 deg throttle (3 in. of Hg manifold vacuum) at 2400 rpm. As can be observed, changing to the modified throttle decreased the rating of the clear fuels and increased the ratings of the leaded fuels.

These two effects combined to produce greater tel effectiveness with the modified throttle. Other Ethyl studies on comparison of fuel injection with carburetion have shown these same effects from improved distribution.

The decrease in clear fuel ratings and the improved effectiveness of tel found with the modified throttle resulted from three factors:

1. By improving distribution, the modified throttle caused the fuel-air ratio in some cylinders to be in the range of maximum knock, whereas no cylinders were in this range with the standard carburetor.

2. Tel response was greater at maximum-knock fuel-air ratio than at lean ratios.

3. The borderline spark-advance framework for the primary reference fuels was approximately the same with both throttle types. The primary reference fuels are quite volatile, and hence they distributed nearly alike with both throttle types.

It was evident from this limited investigation that improved distribution can increase power, fuel economy, and tel effectiveness. The mechanical octane gains are real under certain operating conditions, and they have been measured in terms of increased knock-limited power.

In these investigations, distribution was more affected by the position of the throttle plates than by any other operating variable. In this engine, for example, the adverse affects of throttle-blade position were greatly minimized by shifting the throttle-plate axes 90 deg in the horizontal plane. The resulting improved fuel economy reduced octane requirement for a given power output and gave higher tel effectiveness.

It seems clear that, if engines are to use gasoline with maximum efficiency, variations in the quantity and quality of fuel going into the various cylinders must be minimized . . . . and that this can best be done by careful attention to carburetor and manifold design.

To Order Paper No. 6T . . .
. . . on which this article is based, turn to page 6.

how to STEP UP

Charge stratification —and good

Based on paper by

L. D. Conta and P. Durbetaki
University of Rochester

PART-throttle efficiency jumped 20% when a two-chamber engine was used to stratify the charge in recent tests at the University of Rochester. The increase in brake thermal efficiency was found when the single-cylinder engine was run with a regular throttle and with a charge stratifying fuel injector.

The system used is shown in Fig. 1. The combustion chamber is divided into a small and large chamber. The small chamber contains the spark plug and intake valve. It is in this chamber that the gasoline air mixture is always kept near the theoretically correct value. The large chamber is charged with air only at very light loads and with a normal mixture at or near full load. At light load this has the effect of decreasing the fuel-air ratio and thus reducing the peak cylinder temperature. The re-

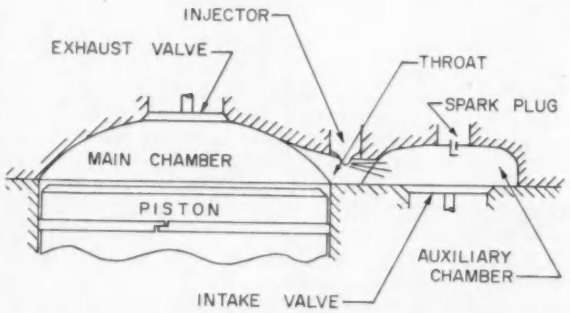


Fig. 1 — Charge stratification is accomplished by injecting fuel into the smaller of two chambers. Injection timing determines amount of fuel in main chamber.

Fuel Economy

shows a 20% boost to part-throttle efficiency

detonation performance at high compression ratios.

duced peak temperature improves the thermal efficiency.

The stratification effect is controlled by the timing of the fuel injection. When operating at full load the injector discharges fuel during the intake stroke. Fuel is, therefore, mixed with all the air in the engine and both chambers have a normal strength mixture. For light loads the injection is delayed until the compression stroke just begins. Since the air is now moving backwards, no fuel reaches the large chamber. However, the small chamber has a normal mixture that can be ignited by the spark plug.

This system eliminates the need for a throttle because the engine is always operating at wide-open throttle. The control of the engine is by the time and quantity of fuel delivered by the injection pump. This gives the efficiencies of a diesel engine at low load without the corresponding strength and weight problems of a compression-ignition engine. Also, injection does not occur during the peak pressures of the compression stroke.

Other advantages of the system are resistance to detonation and lower pumping losses due to the elimination of the throttle and carburetor venturi. Detonation is retarded by making the mixture in the large chamber somewhat leaner than stoichiometric and that in the small chamber richer. In tests runs with an 8.15/1 compression ratio, no detonation was heard up to half loads even when the engine was run on normal heptane, kerosene, and diesel fuel oil. The same engine detonated at all part-throttle loads when it was run by the throttle-charge method.

The tests were made on a 5.5 × 6 model XR "T" head Palmer engine modified to permit operation under stratified charge conditions. The engine was equipped with a modified carburetor that permitted optimum mixture ratios. During stratification runs the throttle was wide open and the carburetor gas flow shut off. Injection was by a Bosch pump (APE-B-60P).

Two compression ratios were used during the runs — 7.24/1 and 8.15/1. The throttle-charge run was used as a base line and the stratification-charge run was compared as a percentage increase. The results are shown in Fig. 2. (The first point for the 7.24/1 compression ratio curve is believed to be in error.)

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. . . on which this article is based, turn to page 6.

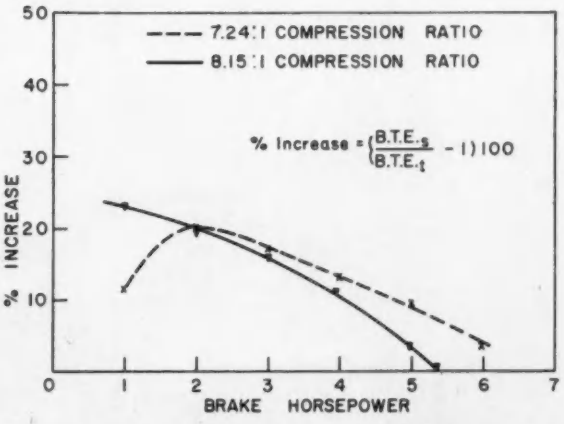


Fig. 2 — Brake thermal efficiency is improved up to 20% when charge stratification is used. Curves shown difference in efficiency between normal carburetion and stratification for test runs on same engine. (Lower left test point is believed in error.)

GMC Light-Weight Highway

Based on paper by

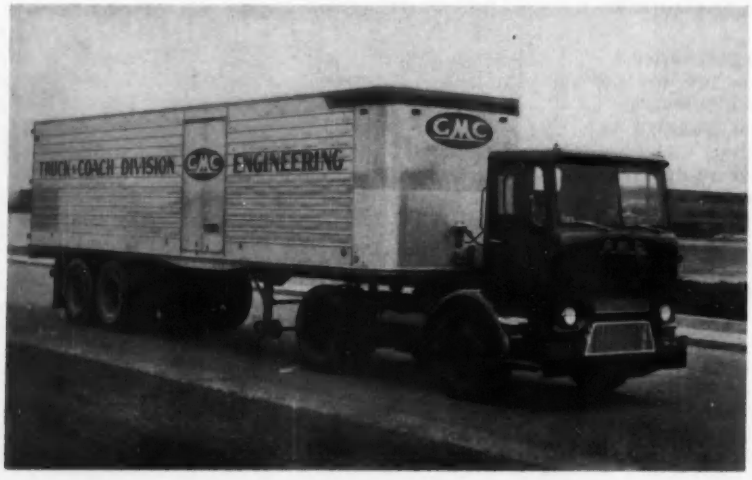
C. V. Crockett and D. J. LaBelle

GMC Truck & Coach Division, General Motors Corp.

A tractor designed for the specific purpose of hauling a single trailer with gcw of 61,000 lb has been developed by General Motors Truck & Coach and is now in production.

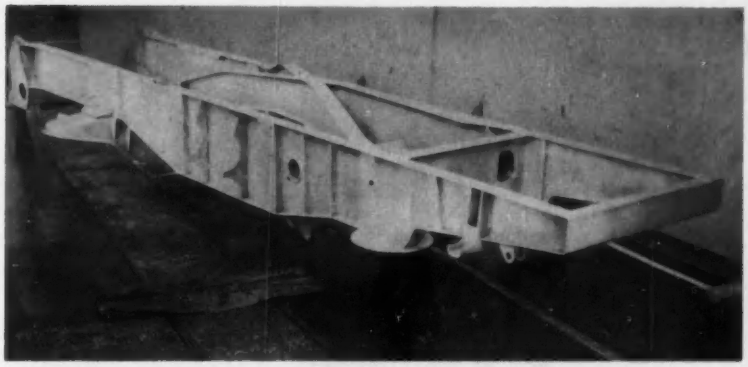
Performance characteristics sought for this tractor were an ability to haul heavier loads and bulkier loads, at a lower operating cost, with greater comfort and safety than found with conventional COE design.

To reach these goals, unusual features were incorporated in the frame, air suspension, brakes, and cab. These are illustrated with explanatory captions on this and the following pages.

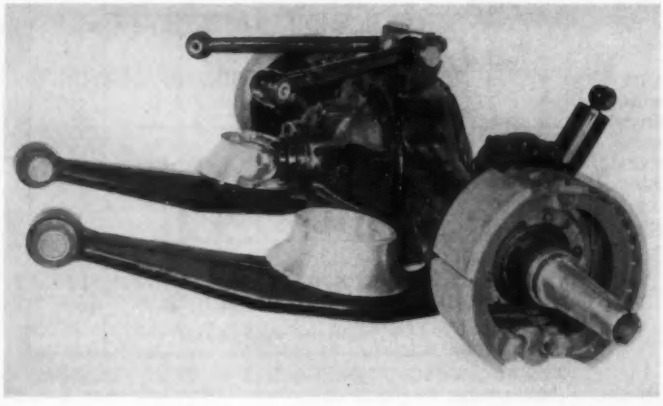


POWERED WITH THE 6-71 GM 2-STROKE DIESEL, this highway tractor has a ready-for-road weight of 10,000 lb. Light-weight construction and heavier load on the front axle give it unusual payload capacity.

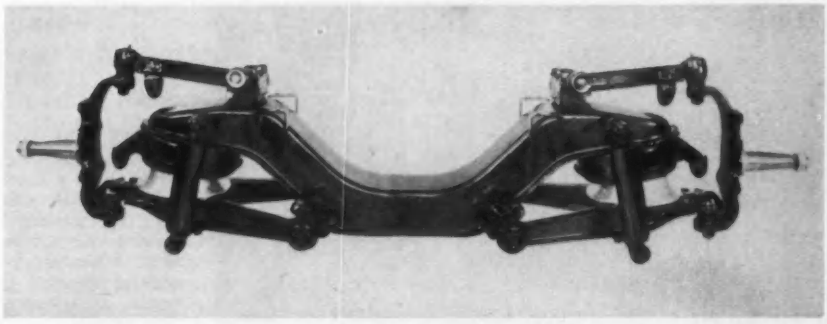
Tractor



FRAME IS OF CRUCIFORM DESIGN, made in varying depths of section by blanking the web panels to the required shape, bending the strip stock flanges to suit, and welding the flanges to the webs. Although 400 lb lighter than the conventional channel frame, it is 1.6 times as stiff in beaming and 27.8 times as stiff torsionally.



AIR SUSPENSION is a four-member linkage system which reduces vibration to permit lighter weight construction of the vehicle. Elimination of static spring deflection allows the fifth wheel and trailer floor to be dropped 3 in., thus increasing payload cubic capacity. Frame construction was predicated on use of this suspension.



INDEPENDENT FRONT SUSPENSION is conventional except for steering gear location in front of wheels and longitudinal drag link extending from the suspension idler forward to the gear. Front cross-member, control arms, steering knuckle, bump stops (and brakes and wheels not shown), can be assembled as a unit, then secured to frame assembly.

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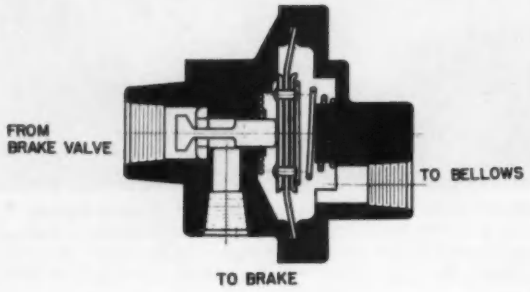
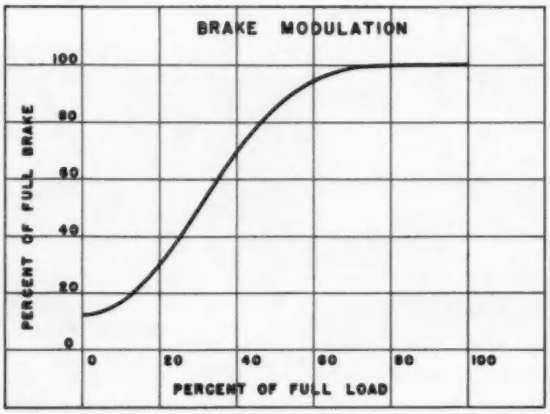


BRAKES HAVE A REGULATING VALVE, shown here in cross-section, which automatically divides the braking effort between front and rear wheels in proportion to the load on them. Its use is made possible by the air suspension. The rear bellows air pressure is in the chamber on the right side of the diaphragm. On brake application, air that supplies the rear brakes enters the chamber on the left side of the diaphragm. When air brake pressure approaches the proportion established by the areas and the spring, the valve closes, limiting the pressure to the value shown in the chart, next.

RELATIONSHIP BETWEEN THE AIR PRESSURE within the rear bellows and the maximum air pressure available for the rear brakes shows how braking effort is proportioned to the static load. The regulating valve also acts to correct transient shifts of weight from tractor rear axle to front axle during braking deceleration. Fully loaded, vehicle weight on rear wheels is 18,000 lb, front wheels 11,000 lb. Without trailer, loads are 7200 lb front and 3000 lb rear.



CAB IS MADE OF RIVETED ALUMINUM PANELS and weighs 696 lb complete. Universal joint in steering column located in line with tilt center allows cab to be tilted without steering disconnect. Gear shift and hand brake levers are located on an island to the right of driver. Sleeper cab can be used without altering fifth-wheel location, trailer length, or proportionate load on front and rear wheels.

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turn to page 6.

Missile Ground Support

. . . is too complex, too costly. Problems are aggravated by fluid state of missile design.

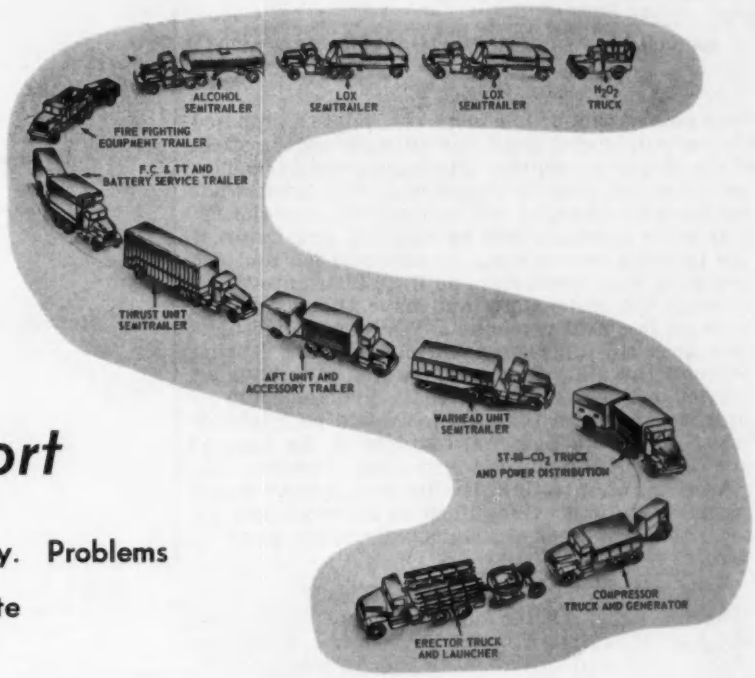

Fig. 1 — This caravan of a dozen vehicles represents the launching unit of a missile ground support system. In addition, a substantial amount of equipment remains at a support area some 30 miles distant from the launching site. This complex GSE accounts for more than 50% of the missile system dollar.

Based on paper by

B. J. Meldrum

Chrysler Corp.

MISSILE ground support equipment, although used over and over again, is so complex and diverse that it consumes over half the missile system dollar and contributes more than its share of headaches. Complexity is, in fact, one of four major problems faced, the others being maintenance of compatability between missile and the GSE, the getting of accurate and reliable feedback of experience from the field, and the maintenance of the GSE itself.

Problem of Complexity

Even a casual appraisal of large ballistic missiles at the present state of the art reveals a staggering complexity. There is just too much of the stuff. A fair impression can be had by looking at Fig. 1 which shows a launching unit caravan on its way to a launching site. And that isn't all. A considerable amount of equipment remains in a support area some 25–30 miles from the launching site.

Complexity has prompted enormous pressures to simplify, which will take major technological breakthroughs to achieve. Progress is being made in the direction of more compact and lighter warheads, which will permit smaller and lighter missiles for transporting the warheads. This in turn will permit the development of lighter and more compact ground support equipment.

Genuine progress is being made with solid propellants and storable liquid propellants. This will eliminate liquid oxygen plants. Progress is also being made in the miniaturization and "transistorization" of missile electronic gear, which will lead to substantial reduction in electrical demand in related GSE. The ideal would be a one-wheeled package of GSE, for one missile, both operated by one man, and the entire complex capable of being lifted by helicopter. We are a long way from this ideal, but progress is being made.

Problem of Compatability

It is urgently necessary to maintain compatability between a missile and its related GSE. The rate of change in ballistic missiles is staggeringly high. At the same time there is heavy pressure to reduce the lead time from weapon system concept to field deployment. To compete with potential enemies the time must be reduced from five or six years to perhaps two years, which means that deployment arrangements must be made while the missile system is in a violent state of flux as far as design is concerned. This is not conducive to compatability.

Once a system has been deployed, opportunity for making changes shrinks rapidly. A change easily and quickly made in the development stage now be-

comes almost impossible to make. Before a proposed change can be evaluated, one must review the effect of the change on delivery schedules of the parts, how the manufacturing inventory will be affected, what obsolescence changes will be involved, how the repair parts inventory will be affected, how many of the training manuals will require revision and the length of time required to do it, to distribute them, instruct the instructors, and have the instructors instruct the field personnel. While this investigation goes on, other proposed changes are flowing through the mill, each one of which may have an impact on every other. If these changes could be processed one at a time the job would be relatively easy. If there are several hundred in the float at any one time, it requires a firm grasp of systems engineering and intestinal fortitude to produce sound recommendations. Simplification achieved through technological break-throughs will bring progress here.

Problem of Feeding Back Experience

Accurate and reliable feedback of experience from the field is essential to a sound system. It can be obtained only if the field instrumentation closely parallels that existing at the supplier's plant. This is particularly true with complex electronic components, such as are used in guidance and control mechanism.

Marked benefits are derived from having functionally identical instrumentation at the subcontractor's plant, at domestic military command headquarters, at domestic testing sites, and with the deployed equipment overseas. The components used are highly advanced technically and variations in test equipment can lead easily to variations in observed data. One should visualize the missile guidance system not as a collection of "on missile" components, but rather as an integrated collection of "on missile" components and "off missile test equipment," which is separated for only a very brief period of its useful life. Data obtained from such a system can be accepted as valid and can be used with confidence in planning new development programs.

Problem of Maintenance

Maintenance of the GSE itself constitutes a major problem. Our field engineers are now reconciled to the fact that GSE will always require more maintenance and will always give more trouble than the missile proper. The latter is now considered to be the simplest element in the system. The psychological problem of maintenance is admittedly enormous. Why should the GI faithfully perform prescribed routine maintenance and functional checks day after day? Why do it the 100th day when it has worked 99 days in a row. Yet, failure to do it on the 100th day may spell the difference between success and failure when the chips are down.

To Order Paper No. 5T . . .
. . . on which this article is based, turn to page 6.

Torsion-Type

employing rubber can

application in car,

Based on paper by

James H. Kramer
B. F. Goodrich Co.

ELIMINATION of bearings and lubrication, and reduction in harshness and noise level are among the advantages of the torsilastic torsion-type spring which make it promising for car and heavy vehicle suspensions.

The torsilastic spring, shown in Fig. 1, comprises an inner shaft, an outer shell, and a cylinder of rubber bonded to both shaft and shell. The metallic inner and outer members are usually made of steel although aluminum, brass, and cast iron have been used successfully.

The outer shell, in this instance, is split into two 180-deg segments. Splitting the shell serves three major purposes. First, it permits high pressures to be applied to the bond between rubber and metal during cure. This is necessary to get satisfactory adhesion. Second, it permits the rubber to shrink after cure without causing internal tension. Finally, its purpose is to compress on the split shell during assembly, placing the rubber and rubber-to-metal bond under radial compression to give increased flex life.

Application to Vehicle

The springs are stressed in torsion by anchoring either the shaft or the outside shell to the chassis and rotating the other member through the use of suitable connections. It is an inherent characteristic of the springs to be able to accommodate any sort of misalignment and they are well suited to serve not only as an elastic medium or spring but also to form a bearing or locating device for the wheel support arm or linkage. When used to serve both purposes, the torsilastic spring eliminates bearings and effectively insulates the road wheels from the chassis.

Action of the spring can be seen by reference to Figs. 2 and 3. Fig. 2 shows a bus spring mounted in a torsional test machine without load. Note the

Abridgment of an
SAE Montreal Section Paper

Spring . . .

be designed in different sizes and shapes for varied

truck, and bus suspensions.

radial white lines on the rubber surface in this relaxed position. Fig. 3 shows the same spring under torsional load. The white lines are now curved, showing the angle of windup in the rubber.

With some understanding of the proposed use of a spring and the characteristics desired, a unit can be designed for the particular application. For passenger car independent suspension using two springs, one in the upper arm and one in the lower, having roughly 7- to 12-in. static deflection and 8-in. wheel stroke that is plus and minus 4 in., a static shear stress at the rubber I.D. up to about 130 psi, with an optimum at about 120 psi, gives satisfactory results. This figure can be increased somewhat as the hardness of the rubber is increased.

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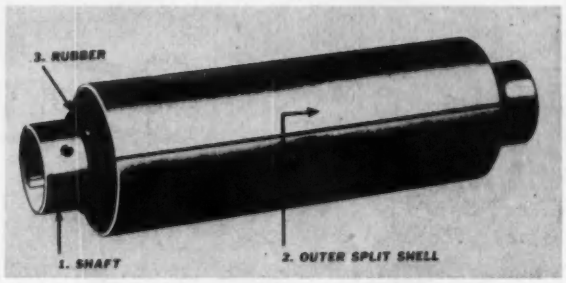


Fig. 1 — Torsilastic spring with rubber cylinder bonded to an inner shaft and outer shell, both of metal. It can serve as a bearing or locating device for wheel support arm or linkage as well as a spring.

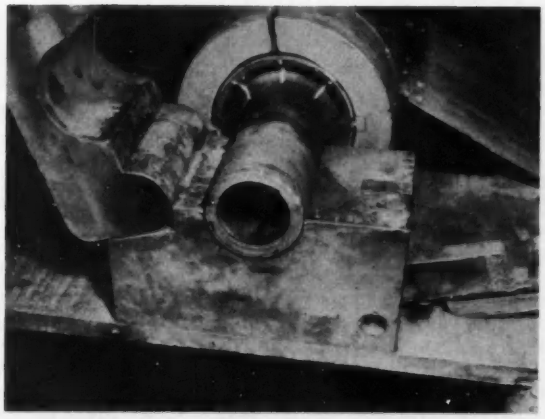


Fig. 2 — Bus torsilastic spring mounted in a torsional test machine without load. Note the split shell and beneath the split the white radial lines on the rubber surface.

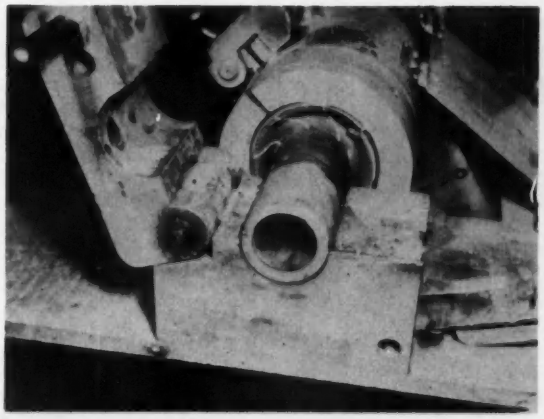
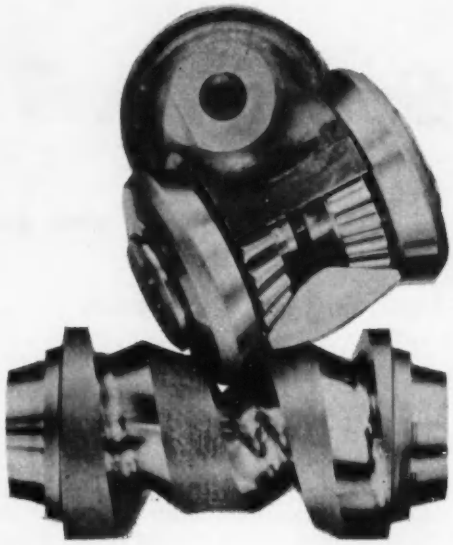
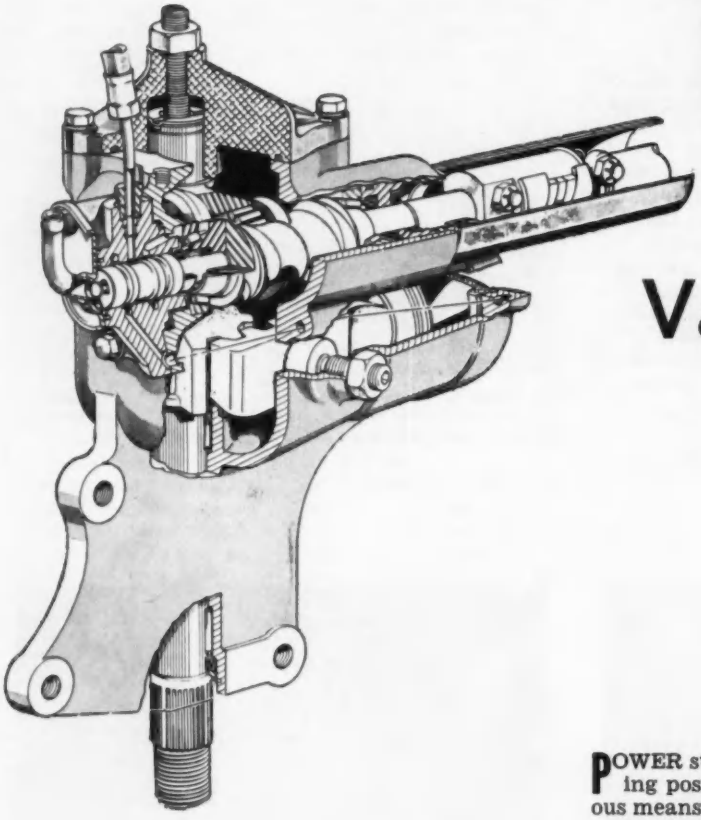


Fig. 3 — Same bus spring as shown in Fig. 2, but with the shell rotated while the shaft is held rigidly, corresponding to a torsional load. The straight white radial lines are now curved, indicating the angle of windup in the rubber.

VARAMATIC STEERING GEAR employing twin follower design is illustrated in the photographs shown at the right. In-line position is shown in the center. With about a half turn of the wheel, contact changes over from barrel surface of one roller to flank of opposite follower continuing in mesh.

HOW THE VARAMATIC CONCEPT might be incorporated in an integral steering gear design is shown below.





Variable Ratio

. . . the next step

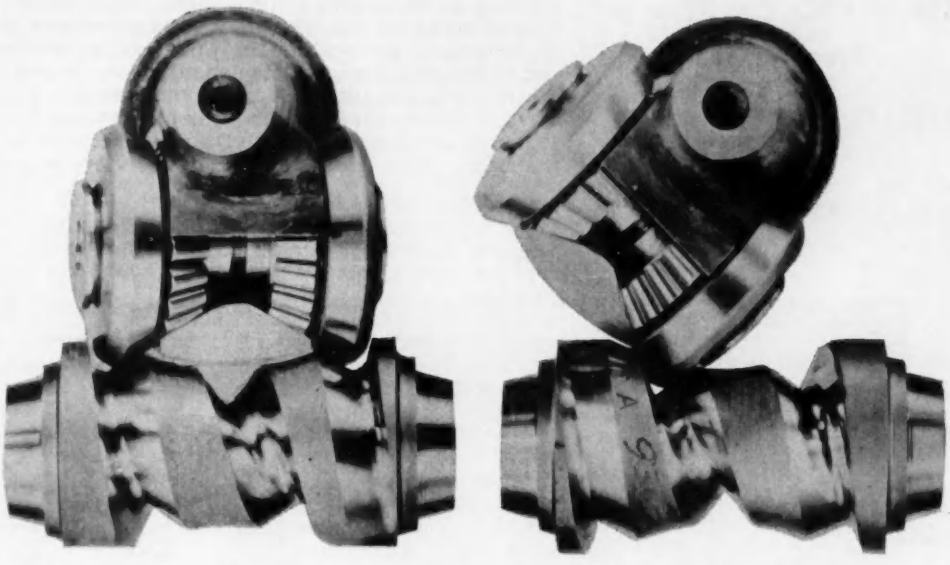
Based on paper by

A. E. Bishop

Bendix Products Division, Bendix Aviation Corp.

POWER steering's greatest significance lies in making possible a return to directness. Of the various means to accomplish this, the most immediately available is through variable ratio employing hyperbolic form curves. This development will give the large car the maneuverability of the sports type, yet provide easy and relaxed high-speed driving in a way not possible in a small car.

The term Varamatic has been used to define a steering gear whose ratio varies more or less in a hyperbolic fashion. With this system, most of the advantages of the speed sensitive steering gear are retained, but the path curvature would be unvarying with the car's speed. Driving habits would not be



Steering Gear

in power steering?

A variable ratio steering gear would restore directness to steering, afford greater maneuverability and safety.

interfered with, though they would be somewhat modified as compared with standard steering.

Varamatic Steering

A number of laboratory-model-type steering gears were built at divisions of Ford, Chrysler, and GM to study the effect of ratio changes in cars of various handling properties. To have the greatest flexibility in ratio patterns, a type of universal hourglass worm and follower were used to provide the mechanical connection. The valve was actuated by a mechanical reaction system having rapid response. The steering gear was constructed so that contoured valves could be substituted with the steering gear in the car. These valves provided a wide range of boost curves and hundreds of combinations were tried.

Fig. 1 (see next page) shows ratio curves for four Varamatic cams covering a range from 2¾ to 1¾ turns stop to stop, compared with a standard 22/1 steering gear having 4¼ turns. The five sectors show the angles of turn of the steering wheel for a constant ratio, and the four Varamatic cams with the wheels turned 16 deg, this being typical of an intersection turn. The saving of wheel turns in such corners is a more important measure of the advantage of the cam than the total saving of turns lock to lock. All of these curves with the exception of B have the hyperbolic form.

Designing a Production Model

In all the programs cam A was felt to be about the correct starting point for introducing this variable concept to the public. Accordingly, it was used as the basis for designing a Varamatic semi-integral power steering gear. Semi-integral implies that the valve and actuator are incorporated as part of the

Variable Ratio Steering Gear

... continued

steering box and not carried directly by the linkage. The arrangement of valving on the input side of the gear is necessary in a variable ratio system, otherwise the effort level changes with the ratio in the steering gear.

Fig. 2 shows cutaway views of an early experimental model on the left and a later development on the right. By locating the valve at the bottom end of the gear, a small diameter valve may be used, contributing less leakage for the same fitup. The valve is reciprocated by a rod passing through the center of the hourglass worm from the actuator at the right. With this arrangement the valve is ro-

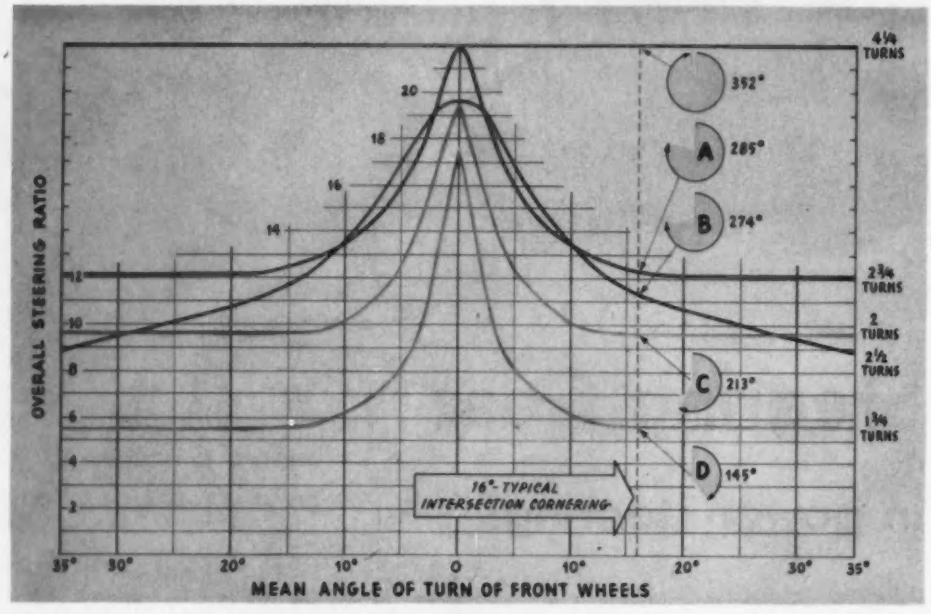


Fig. 1 — Angles of turn of steering wheel for constant ratio and four Varamatic cams with wheels turned 16 deg. Saving of wheel turns at intersections is more important than total saving of turns lock to lock.

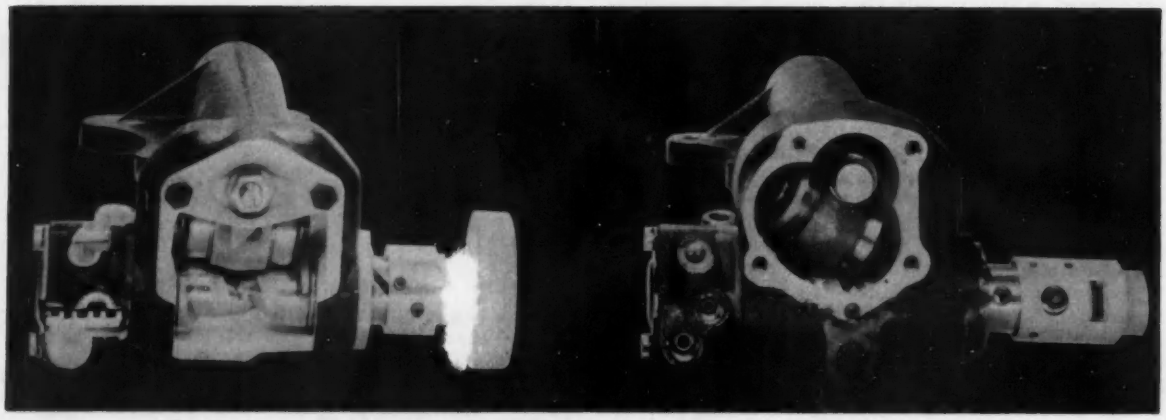


Fig. 2 — Cutaway views of early experimental Varamatic gear model on left and later development on right.

tated as it is reciprocated, hence there is minimum hysteresis or valve loop. The actuator consists of a rubber-lined screw thread. The helically inclined faces provide an axial stroking movement when the input torque is applied to the steering shaft. The rubber provides the centering force to restore the valve to the centered position and at the same time produces the progressive effort buildup which provides the feel. The lead length of the helix can be made to give practically any response desired.

Advantages of Twin Follower

The ratio of the Varamatic steering gear varies from 20/1 in-line to a minimum of 12/1 as the stops are approached. A unique form of hourglass worm is incorporated in the production design, stronger and more economical than the single follower type. The low lead areas occur on the largest diameter, which provides better contact at the more critical and predominantly used in-line position. In contrast, with the single follower the in-line condition occurs at the smallest diameter of the hourglass worm. Rapid lead changes occurring in this area prevent achieving ideal contact conditions.

The two designs have the same effective moment arms but because of the better contact of the twin follower, higher loads can be sustained between the followers and cam and therefore a higher output torque. With the single follower, a large degree of hooking or undercutting occurs at the outside end of the thread, which makes grinding the thread impractical. The twin follower design can be readily ground and little crowning of the form is necessary. And it can be provided with better bearings to transfer the load from the follower system to the pitman arm head.

Action of the Twin Follower

Action of the twin follower design is shown in the photographs at the top of the two preceding pages. The center view shows the system in the in-line position with contact occurring on the more cylindrical sections of the hourglass worm. The clearance between the flank of the hourglass worm thread and the followers can be seen. After about a half turn of the steering wheel, contact changes over from the barrel surface of one roller to the flank of the opposite follower continuing in mesh. From this point on, further rotation of the hourglass worm controls the rotation of the pitman arm between one barrel contact condition and one flank contact condition. Part of its threads are, in effect, used both in right and left turns, and this accounts for the compactness of the design.

The varamatic concept lends itself to incorporation in the integral steering gear design. The sketch at the bottom of page 64 shows one such proposal. The twin follower hour-glass worm actuator and valve are arranged in the same manner as with the semi-integral design. However, passages connect directly between the valve area and the housing in the one instance, and the top end of the power piston in the other. The power piston is connected to the pitman arm through a rack and sector gear, which is readily adjustable from outside the steering box.

To Order Paper No. 19T . . .
. . . on which this article is based, turn to page 6.

Radiotracer Technique Probes . . .

. . . adhesive wear of rings. Preignition effects are studied and dispersant oil additives are evaluated with irradiated top piston rings.

Excerpts from paper by

Richard Abowd, Jr.
Ethyl Corp.

ETHYL is using the radiotracer technique both in the laboratory and in the field to probe the causes of piston-ring wear.

Laboratory Test Results

Since, in the laboratory tests, we were particularly concerned with adhesive wear of the rings, we developed an engine schedule that made adhesion the dominant wear mechanism.

In one series of tests to study the effects of abnormal combustion processes on adhesive wear of top rings, we found that:

1. No wear resulted from knock alone.
2. Wear that did occur was caused by preignition, and the rate of that wear could be very high.
3. This wear probably was adhesive in type.
4. This wear could be produced without destroying the ring.

The third conclusion may need further discussion. Why do we believe that the wear is caused by the adhesive mechanism? Let us consider what has happened in the engine. When the combustion process was started by preignition as early as 100 deg before top center, the beam load dropped about 40%. This drop in load represents work the piston had to do in moving 70 deg crank angle against the expanding combustion gases before it reached the position where the spark normally ignites the mixture. During those 70 deg of crank-angle movement, the piston ring was contacting a cylinder-wall surface that had been ex-

Radiotracer Technique Probes

. . . continued

posed to high temperatures and pressures from the preignited mixture. Most of the lubricant on the cylinder wall was either evaporated or burned. In addition, the expanding combustion gases behind the ring pressed it against the cylinder bore with a force much greater than normal. Thus, conditions for intimate contact of surface asperities on the piston ring and cylinder bore were maximized.

We have more evidence that the severe wear of the piston ring was caused by adhesion. Oil additives with extreme-pressure properties reduced this wear, a result unlikely if the mechanism were abrasion or corrosion.

The adhesive wear effects of two dispersant-type oil additives — an alkaline barium sulfonate and a barium phenol sulfide, at concentrations of 0.25–0.75 weight % barium — were also studied. The same base oil and the same concentration of zinc dithiophosphate were used in all tests. The results showed that:

1. Wear of the chrome plate decreased with increasing barium concentration. This was true with both additives.
2. However, chrome wear with the sulfonate was about 175% that with the phenol sulfide at all concentrations tested.
3. Iron wear with the sulfonate averaged about 70% more than with the phenol sulfide.

Publication of these results should not be interpreted as a castigation of oil additives, particularly those included here. Refiners and oil formulators have done an excellent job of providing lubricants that permit safe and efficient operation of today's high-powered automotive engines. But the harbingers of serious durability problems, especially ring wear, are already amongst us. The solution to adhesive wear appears to be improved additives.

Field Test Results

The problem in the field tests was to collect data on chrome face wear of top piston rings without interfering with the major purposes of the fleet test, which were to determine octane requirement increase and spark-plug fouling with three different fuel blends run in a group of three cars.

Only by using the radioactive tracer technique could we evaluate the effect of the fuel on face wear of the top rings without interfering with the operating procedures already in use.

Moreover, our counting of the 25-ml sample of oil withdrawn from the crankcase was still satisfactory after 25,000 ring-miles — five months after the start of the test. The returned rings appeared in good condition, but with chrome worn through in some spots. In general, it seems that the rings would probably have been good for 10,000 miles more of radioactive test work.

To Order Paper No. 8U . . .
. . . on which this article is based, turn to page 6.

Fluorinated ester fluids come

. . . 500-650 F

Based on paper by

E. C. Ballard and E. E. Sommers
E. I. du Pont de Nemours & Co., Inc.

FLUOROESTER lubricants have the oxidation resistance and lubricity needed for high-temperature jet engine applications. However, they do not yet meet the V.I. and low-temperature properties called for in MIL-L-9236.

Oxidation tests showed that two new fluoroesters merited further examination. They are a fluoroalkyl camphorate and a fluoroalkyl pyromellitate. For comparison purposes, a typical synthetic lubricant used in present jet engines and meeting MIL-L-7808 was also tested. The results of the tests are shown in Fig. 1 and in Table 1.

The tests were made on 25-ml samples using an air rate of 25 ml per min. A copper surface of 10 sq cm was used as an oxidizing catalyst. The test cells were made of glass, stainless steel, and other metals. The nonfluorinated fluid contained 0.5% (weight) of phenothiazine as an antioxidant.

Excellent thermal stability of fluoroesters was demonstrated in a 600-F 24-hr test where two liquids were exposed to the atmosphere. The results are given in Table 2.

The decomposition is based on acid number and corrected for material loss.

Both of the fluorinated lubricants have good hydrolytic stability. This is because there are bulky groups of molecules close to the ester linkage. These groups hinder the close approach of a hydrolyzing molecule. The camphorate reached 50% alkaline hydrolysis within 24 hr but did not proceed further during an additional 48 hr when tested according to the ASTM-94-56T test method. Pyromellitate can be blown with live steam for several hours without undergoing significant change.

The load carrying ability of the two lubricants was checked by a "Rapid" Falex Test and compared with the same nonfluorinated ester fortified with 5.0% TCP. The results are given in Table 3.

The poor matching of the viscosity and low-temperature properties of the two fluorinated fluids are the major problem in producing a lubricant that will meet the advanced MIL-L-9236 specification. The actual properties are given in Table 4.

To Order Paper No. 9R . . .
. . . on which this article is based, turn to page 6.

close to meeting all requirements of . . .

Jet Engine Lubricants

Table 1 — Oxidation Test Data
(24 hr at 500 F)

	Fluoroalkyl		Di-2-Ethyl-Sebacate
	Pyro-mellitate	Cam-phorate	
Viscosity Change, %			
210 F	1	− 9	160
100 F	1	−12	120
Copper Corrosion, mg/sq cm	0.4	0.4	0.4
Used Oil:			
Color	Light amber	Red-brown	Black
Sludge Content	None	None	Heavy

Table 2 — Thermal Degradation of Esters
(24 hr at 600 F)

	Weight Loss, %	Acid No. Increase	Decomposition, %
Fluoroalkyl Camphorate	1.8	0.4	0.3
Di-2-Ethylhexyl Sebacate	7.4	41.7	14.0

Table 3 — Load Carrying Test
("Rapid" Falex Test)

	Load Carried, lb (max)	Torque at Fail, psf	Bushing Temperature, F
Fluoroalkyl Camphorate	3700	90	545
Fluoroalkyl Pyromellitate	> 4500	75	450
Di-2-Ethylhexyl Sebacate			
Base fluid	1150	45	260
+5.0 wt % TCP	1500	45	275

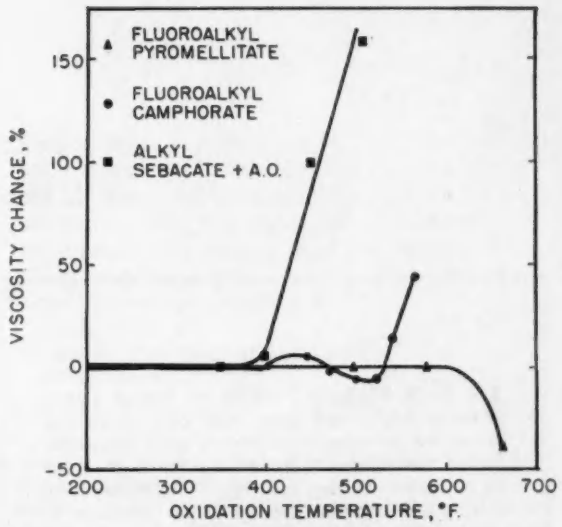


Fig. 1 — Fluorinated synthetic lubricants for jet engines have excellent oxidation resistance at elevated temperatures. Bulk oil temperatures of 450 and 550 F are in the capabilities of the two shown. A regular synthetic lubricant is plotted for comparison.

Table 4 — Physical Properties of Fluoroester Lubricants

	Fluoro-alkyl Cam-phorate	Fluoro-alkyl Pyro-mellitate	Di-2-Ethyl-hexyl Sebacate
Viscosity, cs			
400 F	1.3	2.5	1.1
210 F	8.4	29.0	3.3
100 F	120	716	12.7
V.I.	0	58	154
Temperature Where Viscosity Is 13,000 Cs, F	0	47	−65
Pour Point, F	−25	−5	−75
Specific Gravity	1.60	1.76	0.92
Volatility, 400 F Test, %	65	1	12

Here's a Way to Measure

Based on paper by

L. E. Hebl
Shell Oil Co.

AN EVER-PRESSING NEED to reduce petroleum waste and keep fuel cost down has forced the petroleum industry to make increasing use of the lighter hydrocarbons found in crude oil or formed during refining. (As evidence of this, note that the average vapor pressure of gasoline has increased 1-2 psi over the last 20 years.)

In recent years, the trend toward high compression ratio engines has made it even more desirable to use these light components. Such engines must have fuels of extremely high octane, as determined by the Motor method . . . and the light hydrocarbons: butane and isopentane, when leaded, are among the few hydrocarbons that rate well over 100 octane number by the Motor method (which, because of the higher speed at which the test is run, is more severe than the Research method).

If these light hydrocarbons are to be used to full advantage, it is going to be doubly important that the fuels and the fuel systems of our future cars be designed for each other.

The technique for measuring vapor tolerance of fuel systems described here may prove helpful in solving this mutual design problem of the automotive and petroleum industries.

A NEW technique for measuring the vapor-pressure tolerance of fuel systems has been developed. Briefly, the various factors that can contribute to vapor lock are converted to an equivalent temperature and are then added together to give an expression of the overall vapor-locking condition. Thus, the volatility tolerance of any given car's fuel system can be expressed by the equation:

$$t_a + 115 \log (\text{Rvp} + \text{barometer drop}) + V(2 - S) = C$$

where:

t_a = Atmospheric temperature, F
Rvp = Reid vapor pressure, psi
barometer drop = Pressure drop from 14.7, psi
S = One-tenth of difference between ASTM distillation 10% and 20% temperatures
V = Relative vapor-handling capacity of car's fuel inlet system
C = Constant

C is best described as the temperature tolerance constant of the car's fuel system. It has the same value regardless of the atmospheric temperature at which vapor-lock tests are made. It should be as high as possible.

Application to Cars by Direct Test

Of course, the refiner is interested in knowing what vapor-pressure limits can be tolerated by the entire group of cars in use. For this determination there are several methods of approach, one of which is to run tests on a large number of cars and study the distribution of tolerance numbers (C values).

Unfortunately, the refiner having access to a large amount of road test vapor-lock data is left with a difficult problem of interpretation in attempting to select a tolerance value that he can safely use.

Commercial Data

A more general approach to the problem of defining the volatility tolerance of U. S. cars consists in inspecting the volatility range of the gasolines that have been consistently marketed in various areas. Since there are many days each year when

Fuel System Vapor Tolerance

the atmospheric temperature approaches within a few degrees of the record maximum, the monthly "highest on record" temperature has been used as the basis for gasoline design comparisons, taken from the U. S. Weather Bureau Annual Climatological Summaries. Since the exact vapor-handling constant for those cars that are most prone to vapor lock is not known, a median value of 5 has been used to represent the constant V. The following example uses the most volatile single sample from a group of competitive gasolines to illustrate the method of analysis:

Location and Month	Indianapolis, July, 1958
Highest July Temperature on Record	106 F
Barometer Drop for 715-Ft Elevation	0.4 psi
Rvp of Most Volatile Sample	10.4 psi
Rvp + barometer drop	10.8 psi
115 log (Rvp + barometer drop)	119
Distillation 20% Temperature	145 F
Distillation 10% Temperature	122 F
Distillation Slope (S)	23/10 = 2.3
Slope Correction (Assuming $V = 5$) = $5(2 - S)$	− 1.5
Tolerance Constant (C) = 106 + 119 − 1.5	223.5

The "most volatile" sample is not necessarily the one that has the highest Reid vapor pressure because the slope correction often exceeds the differences in 115 log Rvp.

Table 1 shows the results obtained when the technique is applied to the most volatile sample in each

Table 1 — Analysis of Volatility Data on Individual Gasoline Samples from U. S. Service Stations Reported by Ethyl Corp. over Past Four Years

	Elevation, ft	Barometer Correction, psi	Latitude, deg	Average Volatility Tolerance Constant for Most Volatile Sample Found in 1955, 1956, 1957, and 1958							
				March	April	May	June	July	August	September	October
Albuquerque, N. Mex.	5310	2.6	35	211	217	218	221	220	—	217	209
Salt Lake City, Utah	4260	2.1	41	203	212	217	220	218	218	—	—
Billings, Mont.	3568	1.8	46	205	223	220	220	221	223	—	—
Spokane, Wash.	2357	1.2	48	204	211	220	226	231	222	—	—
Oklahoma City, Okla.	1254	0.7	35	224	221	219	—	226	228	220	217
Fargo, N. D.	895	0.5	47	209	219	220	—	228	220	213	212
Buffalo, N. Y.	693	0.4	43	209	215	222	222	—	216	217	214
Jackson, Miss.	315	0.2	32	212	218	220	219	—	218	—	—
Houston, Tex.	41	0	30	218	213	210	219	218	—	217	—
Boston, Mass.	15	0	42	205	213	220	218	220	213	216	215
Average for 10 cities:				208	216	219	221	223	220	217	213

Here's a Way to Measure Fuel System Vapor Tolerance

. . . continued

group of gasolines, as reported by the Ethyl Corp. in their series of reports on "Volatility Data on Individual Gasoline Samples from U. S. Service Stations" for the past four years.

Note that, with latitude varying from 30 to 48 deg, and with altitude corrections varying from 0 to 2.6 psi, the tolerance value on the most volatile competitive gasoline for any given month is shown to be surprisingly consistent, usually varying less than 5 deg (F).

There are certain consistent tendencies, for example, the area in which volatile fuels are in greatest excess, which would include Oklahoma City, shows a nearly constant tolerance number throughout the year close to 225, which must reflect the month-to-month limiting vapor pressures that refiners in that area have found safe to use.

In mountainous areas such as Billings, Salt Lake City, and Albuquerque, the tolerance numbers are more conservative. This would be expected because cars are driven to elevations higher than the Weather Bureau stations in such areas.

There is some variation from month to month, but it is believed this results from the inability of refiners to maintain the vapor pressure at the safe limit, partly because of the complexity of the blending and distribution systems used in following variations in atmospheric temperature.

The highest tolerance numbers seem to occur generally in July, when the average of Table 1 reaches 223. A few isolated samples exceeded 225 and one reached 231.

To Order Paper No. 1048 . . .
. . . on which this article is based, turn to page 6.

Discusser Questions Value of Author's Formula

Excerpts from discussion by

A. E. Cleveland
Ford Motor Co.

AFTER several careful readings and sincere attempts to manipulate the formula, I am still faced with the unhappy conclusion, applicable also to moon rockets, that I don't know for what useful purpose I would use it.

It appears that another indefinite term C has been added to the already too great multitude of indefinite terms that exist in the language of fuel vapor technology. This one is defined in terms of certain measurable variables — ambient air, fuel distillation curve, and Rvp, and another term called V. V is the only other term not readily measurable with independent ASTM-type measurements.

Now it appears that we have one equation with two unknowns, in which the answer expresses one in terms of the other. The result is philosophically correct, but mathematically and technically useless. For example, the equation tells us that: C (the temperature tolerance of a car's fuel system) is a temperature, fuel distillation, and vapor function of V (the relative vapor-handling capacity of the car's fuel inlet system). This statement is both true and obvious.

Now a solution can be afforded for both V and C in the author's equation by defining vapor-handling ability of the fuel inlet system of the car — as the author has done — in terms of the slope of the ASTM distillation curve and some function of the vapor pressure. Then, the rest of the mathematical manipulation to define C seems a bit superfluous The answer to the relative temperature tolerance or vapor-handling ability, which is, after all, one and the same thing, is already at hand.

Perhaps, the author feels that the ability to attach a number to this new concept C is a desirable thing, which may enable petroleum companies to engineer to such a number much and in the same way as they do the present octane number for gasoline antiknock. If so, I would like a little more feel for exactly what this number represents. Do the volatility tolerance constants shown in Table 1, for example, mean that the combination of gasoline, ambient temperature, and design vapor tolerances will tolerate that liquid in the system? That seems to be implied but not stated. Here again, however, I fall into the problem of the V/L concept when generalizing on a system. Obviously, the temperature that can be tolerated in the fuel tank is different from that in the carburetor float bowl. The problems cited give an average V and also assume that $V \times S$ equals a constant. However, the significance of an average V is still somewhat lost to my mind. For example, a high average V could be obtained by putting a heater and a large vent on the fuel tank and driving off all of the light ends of the gasoline before they get into the vapor intolerant fuel lines and fuel dispensing accessories. This would result in a large V and, by the corollary pointed out before, also a large and desirable C. But is this necessarily good? If it is good, I might suggest that we go a step further and put this heater in at the refinery and drive off the light ends before we get them in the fuel tank. This would raise S and thereby virtually do away with the necessity for V or C.

Around-the-Clock Warmup Testing . . .

. . . of cars and fuels is now a reality. Method of instrumentation uses chassis dynamometer and automatic instrumentation to allow testing regardless of weather conditions and to reduce manpower requirements.

Excerpts from paper by

K. A. Frassa and C. R. Small

Socony Mobil Oil Co.

A method of instrumentation, using magnetic tape to program a test cycle and a strip chart recorder to record engine performance, has been developed and applied to the evaluation of the warmup characteristics of passenger cars on a chassis dynamometer. The relative effects of fuel volatility on warmup, as well as an absolute measure of car performance, can be obtained. Reproducibility of the tests in terms of miles to warmup was 0.4 on the chassis dynamometer as compared to 0.6 on the road.

A block diagram of the instrumentation is presented in Fig. 1. The test cycle is programmed on an Ampex FR-1100 magnetic tape recorder. A continuous loop, of 1-min duration, is used at a tape speed of 3.75 in. per sec. The test cycle consists of constant-speed running at 20 mph for 54 sec and a full-throttle acceleration from 20 mph for 6 sec. The operator manually controls the constant-speed portion of the cycle from the control booth. Two signals, recorded on separate FM tracks, program the acceleration and deceleration portions of the cycle. Track No. 1 controls the throttle position for the acceleration through a pneumatic positioner. The voltage output of the tape is fed into a current-adjustment instrument, which converts the voltage to a 1–5-milliamp signal. This signal is fed into an electropneumatic converter. The converter controls the final positioner, which is connected to the throttle pedal through adjustable linkage. The second track initiates the acceleration cycle and controls the deceleration part of the cycle by closing a relay, which adds an additional load on the system with the dynamometer. The second track also controls the paper drive on the strip chart recorder. This instrument records engine speed and choke position during each acceleration.

Tape programing is a simple operation. First, the output voltage of the manual controller necessary to depress the throttle to the detent position must be determined. This is done by accelerating the car and noting the manual controller output voltage. This is then recorded on tape. The second signal necessary in the programing is a fixed 25-cps signal, which is used to trip a relay at the proper time in the cycle to control the 6 sec of wide-open-throttle acceleration.

The instrumentation permits complete operation from the control booth, thus eliminating the need for a driver and observer. The functions of the operator are limited to starting the car and maintaining constant 20-mph road-load conditions between the accelerations. The Ampex recorder programs the accelerations every 54 sec and brakes the car to 20-mph road load. The operator records peak speeds for each acceleration and observes the engine speed and choke position trace. When the dip reaches a predetermined size for warmup, the operator continues for an additional 5-min to obtain constant peak speeds. The operator then stops the tape, and changes fuels from the booth by means of remotely controlled switches. The engine is then stopped and cooled to the required test temperature. During this cold soak, forced cooling is employed to accelerate the cool-down period.

It is necessary for an observer to ride in each car during the initial test runs to determine the maximum dip size that will permit smooth accelerations. During these runs the wheel chocks and retaining chains are loosened to permit observation of the performance during the acceleration.

To Order Paper No. 6S . . .
. . . on which this article is based, turn to page 6.

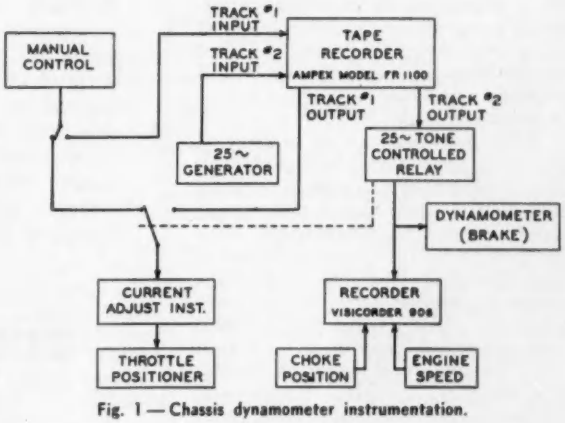


Fig. 1 — Chassis dynamometer instrumentation.

Mechanization and

Based on report by

Wayne Worthington

Deere Mfg. Co.

Russian Mechanization

IT is difficult to compare the degree of mechanization within the Soviet Union with that of the USA. USDA statistics give an annual usage of farm tractors within the USA of less than 800 hr. In the irrigated areas of California and Arizona, it is much greater, ranging from 2000–3000 hr. In the USSR, annual usage was reported at 2000–2500 hr, with most tillage tractors operating around the clock during the limited available time. Average plowing depth throughout the Union ranges from 8½–10 in. But in the extensive sugar beet and potato growing areas, average plowing depth ranges from 12½–13¾ in. On farms in the Ural Mountain area, much of the ground is plowed to a depth of 16 in. every 3 yr. Such deep tillage practices result in a high specific power requirement (hp-hr per acre), which further confuses any analysis of power available.

With the exception of individual plots of land tilled manually by the farm workers, all small grains, sun flower seed, and castor beans are harvested with combines. The largest manufacturer of these is the Rostelmash group, with factories at Rostov-on-Don and Targonrog. This group built 50,000 self-propelled combines, powered with 65 hp diesel engines, in the preceding 15 months. Production is being increased to 65,000 units in 1959.

The Rostov Combine Plant is a huge complex of shops, employing 23,000 people, 30–35% of whom are women engaged in the heaviest manual labor. As in Minsk, a woman factory worker in this "workers' paradise" is given a leave of absence for 78 days prior to the birth of her child, and assuming normal conditions not requiring subsequent hospitalization, for 38 days afterward, a total of 116 days. Like all Soviet factories, Rostelmash includes an entire city within its facilities, with hospital, polyclinic, nursery, kindergarten, recreation park and stadium, classic football team, swimming pool, and a summer camp for children located on the Black Sea. We were unable to determine who was permitted the use of these facilities, and who was excluded.

At present, a plan has been started to effect the conversion of some 200,000 large drawn combines to the self propelled type. A substantial prize has been offered in a Union-wide competition to the engineering group and Institute which produces the design that is finally adopted. Conversion will be made either on the state and collective farms, or in the repair technical stations.

The Russian Economy

A statement of wages and salaries without reference to their buying power is meaningless. However, the following is given as

RUSSIAN MECHANIZATION, incentives, costs, wages, and salaries form the theme for this second installment of Wayne Worthington's observations of his recent 9000 mile trip throughout Russia. Worthington was the lone "industry" member of a 6-man Scientific and Engineering Team sponsored by the U.S. Department of Agriculture under the Soviet-USA Cultural Exchange Program.

The first article, which presented a searching analysis of Russian tractor, farm equipment, and agriculture — present and future — appeared in the February, 1959 issue of SAE Journal.

SAE LOOKS OVERSEAS

A feature of the SAE Overseas Information Committee

Economy—USSR

a basis. The official exchange rate is 4 rubles per US dollar. Tourists have a special rate of ten rubles per dollar, which is closer to the actual buying power. On the basis of wheat delivered at the elevator, the purchasing power of one ruble is $0.085. Communist leadership has recently declared that the collective farms must reduce the price of wheat to the elevators. The state farms deliver wheat to elevators at a price of only 36% of that received by adjacent collective farms, and make a "profit" of 3.27 rubles per bushel. How production costs were determined remains unsolved. As a further illustration of how "administered prices" can get out of line, a 54 hp DT54 crawler tractor sells for approximately the price of 10 ready made suits of very ordinary quality, or 45 pairs of shoes. It requires two months of a factory workers pay to buy such a suit.

Monthly wages and salaries paid in the USSR reported or observed first hand were as follows:

	rubles
Minimum wage in USSR	325
Elementary school teacher	580
Upper grade teacher	780
Physicians in rural areas (70% are women)	850-1000 plus housing.
College instructor	1400
College teacher with MS degree	2700
University professor	3300
University professor with doctorate	4000
University professor with ten-year tenure	5500
Academician	6000

Farm labor was found to be paid as follows:

Collective farm worker (Minsk)	1200–1300
Collective farm worker (Zaparozhe)	1356
Tractor driver	3000–3800
Chairman of collective farm	2500 + 1% of gross income.
Agronomist	80% of what the chairman gets + 1% of crop value.
Animal husbandman	80% of what the chairman gets + 1% of livestock value.
Engineer	80% of what the chairman gets + ½% of gross income.

Factory wages:

Workers (Kharkov)	930 base
Workers (Minsk)	1020 total
Engineers	1300–1500
Technical worker (draftsman)	500–1500
Starting engineer (inexperienced)	900
Division superintendent	2000–2200
Chief engineer (large factory)	2200
Factory director (large factory)	3000

At the Kharkov Tractor Works, when the annual production quota is met, every one from top to bottom gets a bonus of 20% with a further increase of 2% for each production gain of 1% above the quota.

Special payments are made to inventors. The man who developed a tractor mower, which later went into successful production received the maximum cash award of 200,000 rubles. The maximum payment for an "idea" which leads to successful development is 20,000 rubles. A total of 17,000 incentive payments were made to engineers in agriculture in 1957.

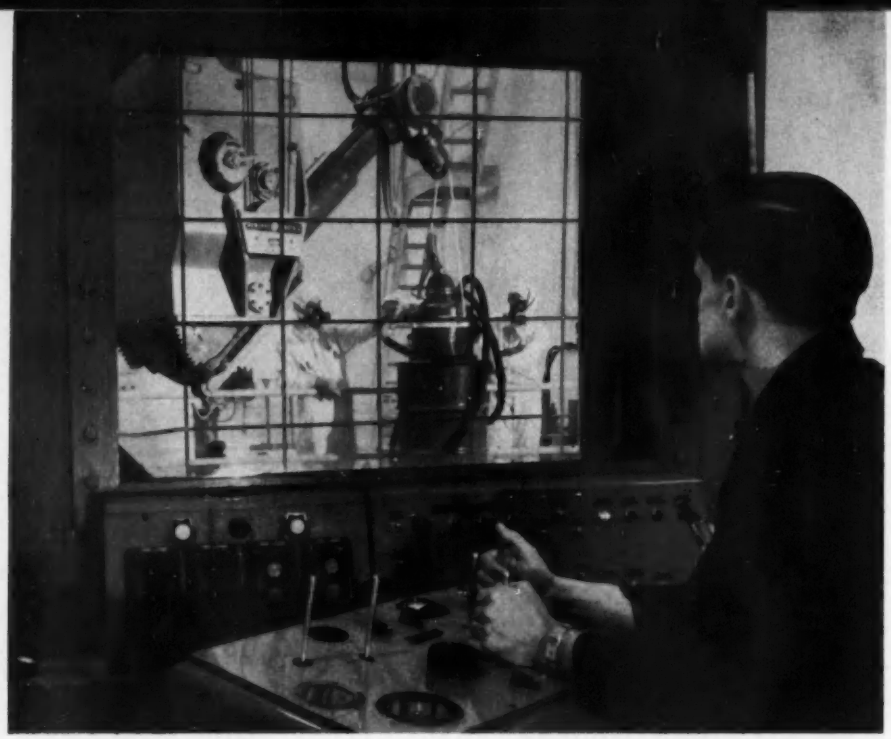
In general, prices are strictly regulated to control production. The following prices were observed.

	rubles
54 hp crawler tractor (800–900 bu. wheat)	17,000-19,000
45 hp wheel tractor with rubber tires (935 bu. wheat)	20,000
12 ft. self-propelled combine with 65 hp diesel engine (750 bu. wheat)	16,000
Butter	12.50/lb.
Margarine	6.60/lb.
Roasted coffee	20.70/lb.
Tea	3.30/lb.
Rice	3.28/lb.
Fat bacon	9.10/lb.
White bread	1.70/lb.
Cocoa	20.35/lb.
Sugar	4.05-4.55/lb.
Flour — first grade	1.80/lb.
whole wheat	1.37/lb.
Small ripe olives	11.42/lb.
Green pepper	1.59/lb.
Holland rusk (domestic)	47.20/lb.

Note: In the bakeries, customers, after standing in line to be served, would take a loaf of bread in their hands, walk to a side table, and wrap it in a used newspaper.

Cotton pajamas	120.00/pair
75 watt electric bulb	3.30 each
Woman's cloth coats — fair quality	300–400
Shoes — fair quality	280–385
Cotton dresses, ordinary	350–400
Men's 2-piece suit — very ordinary	1780

Rents are low, averaging 5–10% of workers' income. However, it is only this year that the rental situation in Moscow has improved to where occupancy has decreased to a single family per room, in a cold water flat, with several families sharing common kitchen and toilet facilities.



MANIPULATOR operator in control room outside of huge hot shop observes operations through multiple thicknesses of glass of extremely high lead content. This hot shop was built for remote servicing of equipment used in connection with the aircraft nuclear powerplant now being developed by the AEC and the USAF.

Nuclear Hot Features Huge

Reported by

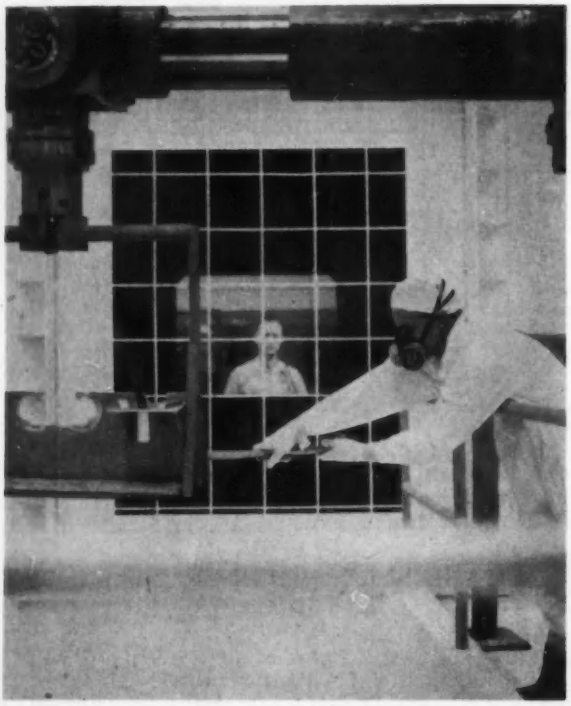
D. R. Shoults

Member, SAE Nuclear Energy Advisory Committee

SPECIALLY constructed 6-ft-thick windows are an important feature of the huge hot shop at AEC's National Reactor Testing Station near Idaho Falls, Idaho. These windows are needed to give the operators of the remotely controlled manipulators used in the shop clear, undistorted vision of the work in progress and still be protected from the radiation environment.

These windows — 96 in. high and 69 in. wide (giving a volume of 145 cu ft) — pierce the 7-ft-thick high-density concrete walls of the shop. They consist of four different materials:

- **White lime glass.**
- **Special shield type A glass.**



TECHNICIAN in hot shop guides manipulator while operator observes proceedings from outside the shop. Windows are 96 in. high by 69 in. wide at the hot shop side and taper to 29-in. height and 65-in. width at control room. Technicians are allowed in hot shop for short periods only when level of radioactivity is permissive.

A feature of the

SAE Nuclear Energy Advisory Committee

CLARITY and good resolution free of distortion are required of the large windows used by operators for following activities within hot shop. Manipulator operator uses binoculars for close-up view.

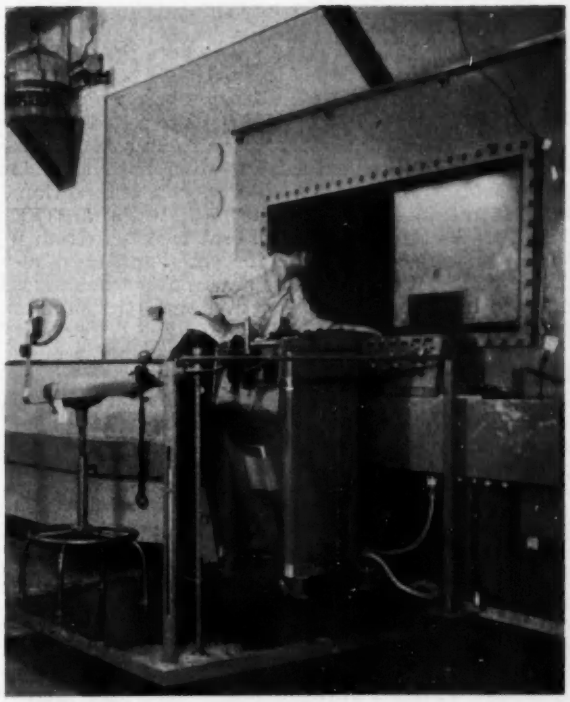
Shop Windows

- Special shield type B glass.
- Zinc bromide solution.

About 500 gal of zinc bromide is placed in each window. The solution attacks many metals and organic compounds, with the result that window seals are a constant problem and special gaskets and stainless steel filtering devices are needed for the drain system.

In 1958, after three years of use, the zinc bromide solution became so cloudy that a cleaning of these vital sources of viewing was needed. They were drained. A scum left by the solution on the window panes could not be penetrated by hydrochloric acid, although particles could be loosened by turbulent flushing with water. After each purging with water, a heavy-foaming detergent solution was pumped into the voids.

When the new solution of zinc bromide was first pumped into the windows, extreme aeration resulted. It took days for the occluded bubbles to dissipate. That's why gravity feed was adopted.



CONTROL ROOM for operators of manipulators in hot shop is protected from work area by 7-ft-thick walls. Windows 6 ft thick contain 500 gal each of zinc bromide. Bottles above each window serve as surge tanks to take overflow of solution caused by windows contracting with temperature changes.

Friction, Wear, and

Based on paper by

Dr. F. P. Bowden

Cambridge University, England

IF WE wish to go hurtling around the earth at a few thousand miles an hour, we must learn more about the way solids slide, bend, and break at very high speeds. To further this understanding, experiments have been conducted at Cambridge University which probe the sliding friction and wear of nonmetals, and the deformation of solids at high rates of strain, particularly the deformation and damage of metals and nonmetals under high-speed liquid impact.

friction of wood

The most revealing results are obtained when steel or polytetrafluoroethylene (PTFE) are rolled or slid over a balsam wood surface. The rolling friction is found to be due to internal friction or hysteresis losses in the wood and not to surface interaction. It is essentially the same with both steel and PTFE spheres. As the moisture content is raised from 0 to 30%, the rolling friction increases and then remains constant. This is due apparently to changes effected in the mechanical rather than the surface properties of the wood.

In contrast, the sliding friction is found to depend both on the moisture content of the wood and on the chemical nature of the other surface. For a hard slider of a given material under specified moisture conditions the sliding friction, F_s, may be expressed as the sum of two terms:

$$F_s = F_D + F_A$$

F_D is the tangential force involved in deforming the wood and is directly related to the internal friction or hysteresis losses in the wood itself: it corresponds to the rolling friction, F_A is the tangential force required to overcome interfacial adhesion, and is specific to the surfaces. It is high for steel whatever the moisture content of the wood, showing that the adhesion, which is probably due to hydrogen bonding, is strong in both cases. For PTFE the friction is fairly high when the wood has a low moisture content, implying a relatively strong adhesion, but it is very low when the moisture content exceeds 30–40%. This emphasizes the importance of surface structure in the adhesion term of friction in contrast to the deformation term, which is essentially a bulk phenomenon.

friction and abrasion of diamond on itself

Studies have been conducted to determine whether the abrasion of diamond by diamond is primarily mechanical or thermal, that is, whether it occurs by fragmentation of the diamond on a microscopic scale, or by some change caused by the local high temperatures produced by friction. These studies cover track formation on diamond, and the friction of diamond.

It was found that, according to the conditions of sliding, tracks of three main types can be produced, and that on an individual diamond face there is no variation of the ease of track formation with sliding direction. This last result contrasts with the large directional variation in the ease of abrasion, and indicates that high sliding speeds introduce some effect which causes the anisotropy in abrasion resistance.

During high-speed sliding the points of contact between the abrasive and the diamond will become intensely hot and local temperatures may reach 1000 C or more and be sufficient to change the diamond into amorphous carbon. This change is thought to be the cause of wear, the soft carbon being scraped away by the oncoming diamond dust.

Work on friction shows there is a variation with sliding direction of the coefficient of friction between diamond and diamond. Directions in which the friction can be high are directions of easy abrasion. The local surface temperatures during abrasion will depend on the coefficient of friction and will be greater when the friction is high. These directions would thus be expected to be those of easy abrasion. Furthermore, a small anisotropy in friction would account for a large anisotropy in abrasion resistance. Experiments show that even the hardest surface of a diamond can be readily polished by a metal if the rubbing speed is sufficiently high. Again there is evidence that this is due to the transformation of diamond to carbon at the high surface temperature which is allowed.

polishing, surface flow and abrasion of diamond and glass

Diamond sliding on glass can, under suitable con-

Deformation of Solids

ditions, induce surface flow of the glass. The speed (v) and load (W) necessary to cause this flow have been studied and it is found that flow occurs only if $v\sqrt{W}$ exceeds a critical value which depends on the type of glass. There is evidence that flow occurs when a critical surface temperature is reached, and appproximate calculations indicate that this temperature corresponds to the softening point of the glass. This type of thermal softening and flow may occur on a submicroscopic scale when glass is polished.

Heavy wear of a diamond sliding on glass has been observed. It is very dependent on the humidity of the atmosphere; in a dry atmosphere it may be 100 times greater than in a humid one. The wear rate of diamond on glass in dry air is greater than on a scaife (diamond impregnated grinding wheel). The wear is accompanied by the production of a detritus of amorphous carbon so that the process appears to be primarily one of degradation of diamond to amorphous carbon. The degradation is aided by the temperature rise at the rubbing interface and there is evidence it can occur at temperatures lower than those required when the diamond is heated without rubbing.

friction of rubber and metallic carbides

Recent experiments show clearly that the sliding friction of solids on well lubricated rubber is due primarily to elastic hysteresis loss within the rubber. These observations may be important in the friction skidding and wear of tires.

The friction of metallic carbides at high temperature has also been studied, with measurements made at temperatures up to about 2000 C. When graphite is slid on itself or on copper or silver it was found, for instance, that the friction fell steadily as the temperature was raised. With graphite on other metals, the friction at about 1000 C rose to a high value due, it was shown, to the formation of metallic carbides at the interface.

friction of solids at high speed

Studies conducted to measure the friction of solids at speeds up to about 1800 mph show that the sliding resistance of metals decreases as the speed increases and reached very low values. There is evidence that frictional heating produces high surface temperatures and a softening and melting of the metal at the regions of contact.

An analysis of the heat flow in a specimen shows that the area of intimate contact is very small compared with the apparent interface. Since the temperature falls very rapidly with increasing distance from the shearing zone, the metal behaves like a combination of a thin film of low shear strength supported by a hard substrate. This can explain the low friction at high sliding speeds. It is also suggested that the real area of contact depends on the velocity with which plastic strains are propagated in the metal. The shearing occurs so rapidly as to make impossible full plastic yielding under the normal load. Some metals disintegrate in a brittle fashion when a critical speed is exceeded.

liquid impact at high speeds

The damage done by a drop of liquid striking a solid surface at very high velocity has been studied with a very simple apparatus. The device consists of a small stainless steel injector into which about 0.01 cc of liquid can be sealed by a neoprene disc. At the instant of firing, a slug from a high powered air rifle rams the disc into the injector. The highly compressed liquid escapes through the nozzle at the far end of the injector as a short, high-velocity jet or cylinder. Information is gathered by high-speed photography.

All metals are deformed readily under these conditions. With a high-strength stainless steel, the main effect of the impact at speeds of 3000 fps is to produce a shallow, saucer-shaped depression in the surface, with a central pit and a highly deformed annular region just inside the rim of the depression. The area of deformation corresponds closely to the area over which the spreading cylinder exerts a pressure. This is, of course, considerably greater than its initial cross-section. The pressure is assumed to be maximum under the center of the collapsing cylinder, and to fall smoothly to zero at points where the liquid flow first becomes entirely parallel to the surface. This can be determined from photographs. The depression formed in aluminum under the same conditions is more than 10 times as deep. Using aluminum targets and a mixture of water and glycerol as the deforming liquid, the intensity of the deformation near the rim was

Friction, Wear, and Deformation of Solids... continued

found to increase with the viscosity.

The failure pattern due to liquid impact in rigid plastics, glass, and ceramics is quite different from that observed in metals. Using Perspex for test, the main feature of the damage was found to be a ring crack. The area of the surface inside the ring is undamaged and for a considerable distance outside the ring the surface is pitted with short, straight, circumferential cracks. Moreover, there is heavy damage of the solid in a localized region beneath the surface. After four or five impacts the various structure surfaces join up, and a large piece of the solid is dislodged from the surface.

As with metals, failure can be thought of as arising primarily from the distribution of pressure under the jet, together with the deformation associated with rapid flow along the surface. Brittle failure may be expected to occur preferentially on planes across which the tensile stress is a maximum. The Hertz theory of contact stresses can be used to predict the regions of high tensile stress in the solid for the given distribution of pressure on the surface. Bearing in mind the limitations of the theory when applied to impact problems, it is possible to deduce that the maximum tensile stress occurs at the surface across the circular boundary defining the limits of the area under pressure. Outside the boundary the tensile stress decreases slowly with distance; inside the boundary it falls abruptly to zero and becomes a compressive stress. Such a stress distribution accounts effectively for the pattern of surface cracking. The theory also predicts that the ring crack should form part of a conical rather than cylindrical surface.

scabbing of back surface

If the specimen is thin, a large scab may be detached from the back surface when the front surface is struck by the liquid. The compression wave set up on impact is reflected from the back surface as a wave of tension, and the associated tensile stress effectively pulls a piece out of this surface. The new surface so formed reflects the remainder of the compression wave, and the process of scab formation is repeated.

That impact from a water cylinder with a velocity of 300 fps can deform materials as hard, for example, as tungsten carbide is not surprising if it is realized that the pressure developed on the surface is well above the yield strength of most common metals. The associated stress may be further magnified by the presence of surface pits. Also, there are the shear stresses associated with the high-speed flow of the collapsed cylinder over the surface. Flow velocities parallel to the surface were observed to be two to three times as great as the impact velocity. Any surface irregularity in the path of this flow would certainly be deformed.

Some of these observations may have a bearing on the damage of turbine blades.

To Order Paper No. 17R . . .
. . . on which this article is based, turn to page 6.

Low Power Coming for

Fred G. Wagner
Convair Division, General Dynamics Corp.

A NEW concept in blown wings promises to give coefficients of lift of 5 or better at greatly reduced pumping power. The system uses both suction and blowing on the same wing and has a jet pump to augment the mass of air blown. This combination overcomes many of the problems encountered in previous blown wing experiments.

Early experiments of conventionally blown wings proved that high C_l values were possible when a jet of air was blown over a trailing edge flap. This stream of air energized the boundary layer and prevented separation. The main problem was the amount of power required to do the job. Another way of accomplishing a similar effect is to suck off the low-energy boundary layer, again preventing separation and giving high C_l values.

Two other problems encountered in a conventional high-velocity jet-blown wing are:

- A large shift in pitching moment.
- High-temperature material for ducts and flaps.

The shift in pitching moment with increasing lift not only causes serious stability and control problems, but also decreases the net effect of the wing lift by the tail forces needed to keep the airplane in trim.

The high-temperature materials are needed because 800 F air at 30 psi is typical of the blown air ambient conditions. Small, high-velocity ducting is used because of space requirements in the airframe. Moreover, proper air distribution over the most of the span is difficult when relatively efficient wide slot distribution is used because of necessary high loss throttling devices.

The new system is shown in Fig. 1. The flap is moved forward on the wing, partly to improve the pitching moment characteristics. Preliminary three-dimensional tests show that this arrangement gives no appreciable change in pitching moment with increasing lift. See Fig. 2.

The use of a jet pump gives three advantages:

First, suction is automatically applied at the trailing edge of the wing. This prevents separation on the upper surface of the wing. Second, efficiency is improved because a resultant larger mass of air is moved at a reduced velocity. As jet pump design

Boundary Layer Control

STOL Aircraft

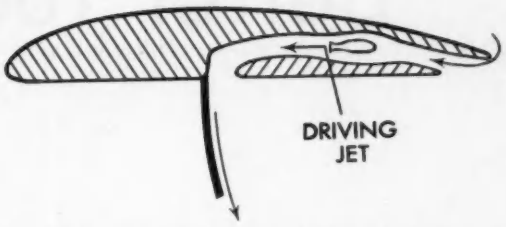


Fig. 1 — New concept of jet induced lift employs mass augmentation and split flap blowing combined with trailing edge suction.

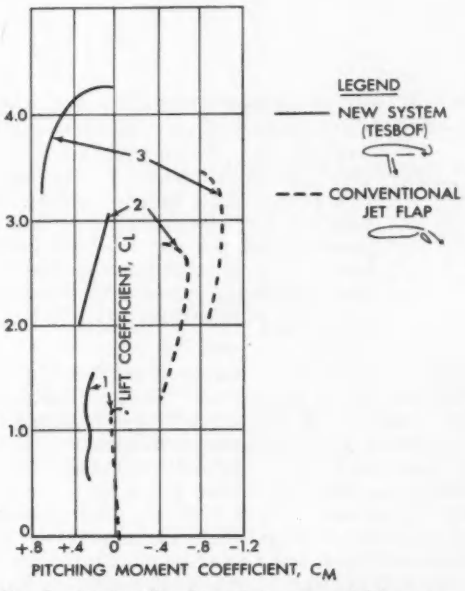


Fig. 2 — Moving flap forward improves pitching moment characteristics. There is practically no change in pitching moment with increasing lift in the new system. Curves "1" are with no boundary layer control. Curves "2" and "3" are for increasing amounts of boundary layer control.

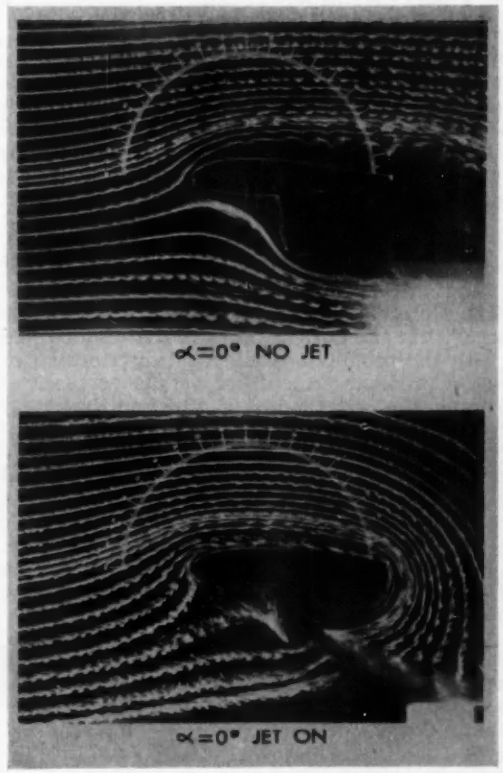


Fig. 3 — Smoke tunnel studies show the extreme circulation possible with the new system. It is possible to move the stagnation point to the lower edge of the flap.

advances, this advantage should increase accordingly. Third, hot gases are mixed with the cool ambient air. The flap and surrounding wing structure can be made of lower temperature materials.

Smoke tunnel tests are shown in Fig. 3. The trailing edge suction and the sink effect of the jet direct the flow around the trailing edge. Theoretical studies and smoke tunnel experiments show that it is possible to locate the stagnation point at the jet exit edge on the lower end of the split flap. Further downward displacements on the jet itself are possibilities still to be explored.

Future studies needed include investigation of the lift capabilities of the basic configuration, slipstream and ground interaction, and the use of the split flap as a trim and control surface.

better technical papers

by Lloyd Withrow

Research Laboratories, GMC

I SHOULD like to begin with a couple of questions:

- For what purpose does SAE exist?
- Why SAE papers at all?

These questions were partially answered at the September meeting of the SAE Council in Chicago. There it was emphasized that the fundamental purpose of SAE is the **development, collection,** and **dissemination** of technical information. To me, this is most important because it is technical information, knowledge, and know-how built up over a period of years that is the heart and soul of our profession — if, indeed, automotive engineering is a profession.

As a matter of fact, I have talked with people who believe that SAE performs more like a trade association than a professional engineering society. These people say that the Society appears to be concerned more with the production, sale, and distribution of automotive products than either the development of new engineering knowledge or the application of sound engineering principles to the design of automotive equipment.

I see nothing wrong with either the professional or the trade association point of view insofar as the automotive industry as a whole is concerned. We must have both if our industry is going to thrive. The question is "Where does SAE fit into the picture and where is the emphasis to be placed in respect to SAE papers?"

For further information on these last two points, I can think of no better source than the Constitution and Bylaws of SAE. I shall take the liberty, therefore, of quoting Section C-2 and C-3 of the Constitution of the Society of Automotive Engineers.

C-2 The object of the Society is to promote the arts, sciences, standards, and engineering practices connected with the design, construction, and utilization of self-propelled mechanisms, prime movers, components thereof, and related equipment.

C-3 The principal means for accomplishing this object shall be the holding of meetings for the presentation and discussion of **professional** papers, the development of technical reports including the engineering standards and recommended practices, and the publication and distribution of same.

The question then seems to be "How well are we fulfilling these objectives?" L. D. Thompson, 1958 Vice-President for Diesel Activity expressed the feelings of many SAE members, in speaking at the SAE Council Meeting in Chicago last Fall. Thompson remarked that, like most other SAE members, he holds membership in the Society to keep himself informed about current developments in his field. Moreover, he is interested in maintaining this situation and asked: "How is the reorganization of SAE going to improve the quality, quantity, and currentness of technical material available?"

He was, of course, discussing the situation from the information receiving end. My remarks, on the other hand, are pointed at the giving end.

The statement that it is more blessed to give than to receive certainly applies well to the participation in SAE. For example, I think that everyone knows that the man who carefully prepares an SAE paper learns more than the many individuals who either listen to or read his paper. The same applies to those who assemble information for technical committees. For this reason, it is indeed fortunate so many SAE members participate actively in our affairs.

Still, we are faced with an important dilemma when we consider the SAE membership as a whole. The great majority of us have opportunity to participate in only a few of the many SAE affairs. SAE interests are so broad, in fact, that none of us can take part in everything. It therefore becomes the responsibility of those who do participate to do the best possible job of informing the rest of the membership of the progress made in the various activities. These progress reports must be carefully and

for SAE

accurately prepared, easy to read, easy to comprehend, and to assimilate. In fact, the best we can do in preparing this material is none too good.

Returning now to L. D. Thompson's expressed request for improved quantity, quality and currentness of technical material, we might ask ourselves a very pertinent question.

Where does technical material of improved quantity, quality, and currentness come from?

There is no simple answer, but I think we can safely say that much of it comes from new and original research and development work which has been accurately and carefully carried out. It comes from our own research and engineering laboratories, and if we want better SAE papers, the place to begin is with better research and engineering at home.

I now want to make an additional pertinent point. Conceiving and carrying out an excellent bit of research or development is in itself not enough. If the new and unique work is to have its rightful impact on the automotive engineering profession, it must be communicated to the SAE membership in understandable fashion. Those who read or listen to presentations of technical material must be able to fit the information in with other knowledge already in their possession. When such presentations are not made, excellent work is often overlooked, and later those who were ingenious enough to do the excellent work frequently complain because they do not get proper credit for their efforts.

Now, I want to put on the record just a few of my personal gripes about the preparation and presentation of SAE papers.

Let us begin by considering the preparation of a technical paper from a professional point of view. Let us assume that we are reporting something new and unique. **It is most important that we indicate clearly wherein the work is new, how it differs from the work of our contemporaries.** This means that we must give our fellow SAE members credit for what they have done and show where we have added to available knowledge . . . knowledge which is the substance of our profession.

Preparing a paper of this kind is not easy. Moreover, it requires a high degree of intellectual hon-

THIS IS THE MOST provocative article on an important phase of SAE that the Journal has been privileged to publish in recent years.

The author, an active contributor to SAE literature and committee work for more than 20 years, speaks his mind about SAE papers. Pulling no punches, he decries testimonials in technical papers, deplores "the indiscriminate integration of technical and commercial papers that gives people the wrong impression about SAE" . . . and urges engineers when presenting SAE papers to "treat your fellow engineers as if they were professional men, not as if they were customers."

He wrote the article at the request of the SAE Meetings Committee which long has been exploring ways to get better technical papers for the Society of Automotive Engineers.

Lloyd Withrow is 1959 SAE Vice-President representing Fuels and Lubricants Activity . . . and is head of the Fuels and Lubricants Department of GMC's Research Laboratories.

Lloyd Withrow

better technical papers for SAE

... continued

esty. How many times have we heard papers dealing with engines, transmissions, or other devices where the authors take credit for the developments they discover on their competitors' products. If no improvements on old art have been made, why not simply point out the source of the idea behind the new developments. It will raise the stature of the engineer in the eyes of his contemporaries and make him a better man.

In presenting a paper for SAE, our members have real opportunities to establish themselves as authorities in their fields. They can make real contributions to the profession of automotive engineering, or they can give the SAE membership the impression that they are illiterate and capable only of sloppy engineering and research. Authors of papers have opportunity to enhance the reputation of the companies they represent. They have an equal chance to destroy the good standing of their employers.

Let me take this opportunity to compliment those companies who appreciate the publicity value of good technical presentations. Fortunately, SAE has several of them. Their management's recognize that high-quality research together with better understanding of our problems determine where our profession is going to be in the future. These things also determine where companies are going to be in the future, whether they are going to be business leaders or "also rans." Accordingly, I believe that much of our trouble with poor SAE papers will be overcome when company managements awaken to the fact that quality of technical work and future economic health go hand-in-hand.

In continuing, my remarks would not be complete if I did not mention that the management of some companies consider an SAE paper as an instrument for free publicity for their products — not as a means of providing the SAE membership with new and unique material which will contribute to our profession.

It was, in fact, a couple of papers of the latter type together with indiscreet remarks on my part that led to the invitation to speak on "Better Technical Papers for SAE." One of the papers in question described a new product in terms of testimonials rather than in terms of sound technical data. I have nothing against testimonials in their proper place. In my opinion, that place is before trade associations, marketing groups, or sales organizations. I personally do not believe they have a place in technical discussions before an Engineering Society.

Speaking of ways of selling your product, or rather of selling yourself, the late Bill Knudsen once told a story that I shall long remember. Said Bill: "There are two ways of going about this business. One is to be blunt and blatant about it. You go about the country bragging about yourself. The other is not quite so direct. You spend your time telling everyone what a hell of a fellow the other guy is."

The other paper that got me into my present predicament used both of the procedures outlined by Knudsen. The manuscript had to do with the development of a lubricating oil by XYZ Oil Company. After spending many pages going into many details and comparing the product with competitive oils A, B, C, and D under many alleged adverse conditions, the SAE membership was informed that in the event they wanted to try this new and wonderful product, the trade name was XYZ Divine, and it could be had at any XYZ service station.

Most of us will agree, I believe, that this is a flagrant example of commercialism in a supposedly technical paper. However, there are those who believe that XYZ Oil Company should be given the opportunity to discuss the virtues of their new product before the SAE membership; in other words, that, we should allot time for commercial-technical sessions. For example, it is customary for SAE to invite the equipment manufacturers to discuss new designs of new products, so why not invite the oil companies to discuss their new products. As far as I am concerned, commercial sessions are perfectly proper if the SAE membership wants them and if the sessions are properly labeled. It is the indiscriminate integration of technical and commercial papers that gives people the wrong impression about the performance of SAE.

The essence of my argument then is that better papers will come to SAE when both the membership and company management truly recognize automotive engineering as a profession and assume the proper attitude toward our Society.

In all professions, proper attitudes are very important. For example, this requirement was recognized by the late Miller Huggins, one of the best and most successful managers the New York Yankees ever had. His advice to his players "When off the field, dress like champions. When on the field, play like champions, and above all, be champions." The combined result of this attitude together with ability to play baseball is a matter of record.

Similarly, in the case of SAE, it is not a question of our ability to do automotive engineering. We are simply talking about our attitude. We therefore might paraphrase Miller Huggins' advice slightly and conclude with the following: When conceiving and executing research and engineering, think like professional men. When organizing and writing SAE papers, write like professional engineers, and when presenting your papers, treat your fellow engineers as if they were professional men, not as if they were customers. If all SAE members will follow this simple advice, we shall soon develop into a truly great profession, and our standing in the community will rise accordingly.

Abridgment of an
SAE Philadelphia Section Paper

Shoe Box to Air Liner

That's the style change buses need to hold their own in the transportation picture.

Based on paper by **G. E. Mintz** Mack Trucks, Inc.

BUSES need to be made more attractive to passengers if city transit systems are to meet competition from the private car and stem the falling off in passenger revenue.

Here are suggestions for design changes to improve appearance and comfort, based on surveys made to determine the opinions of bus operators and passengers.

exterior design

To get away from the present box-like design some compromise must be made and that will have to be in the number of seats. Sacrificing two seats would permit real styling of the front end and improve vision for everybody.

Present straight sides are fatal to appearance. They have been necessary in order to permit sash to be moveable. With the perfecting of air conditioning, fixed sash can be used, permitting large curved window areas to be incorporated in the body design. This will improve appearance and passenger vision.

doors

Door openings should be double width and the doors should slide. Until methods of fare collection are changed, extremely wide, or even three doors, should be considered for the right hand side of the bus. A single combined front entrance and exit door would enhance appearance and passengers would have less fear of missing their stops. Also, loading and unloading time would be shortened.

bus width and floor height

In major cities, an overall width of 102 in. or even 104 in. would be desirable. This would give greater passenger comfort.

Elimination of steps would be ideal but necessitate too many radical changes. A practical compromise would be one step about 9 in. in height instead of the present two, and perhaps keep this height over an area from the front of the bus to a point immediately to the rear of the exit door. From thereon to the rear of the vehicle would be a second level.

interior design

Seats should be deeply cushioned and they could well be of the modern, molded, body-contoured type. They should be wide enough and spaced so that passengers don't touch each other. In limited width buses, a single seat on one side and two seats on the other might be necessary.

Improving interior comfort and exterior styling of the present 40-ft bus would, in our opinion, result in 39 seats compared with 50 as now. This capacity would still be adequate for satisfactory off-peak service which operators are seeking desperately and it would give greater standee area for peak periods.

Seats could be supported from the side panels and from a vertical stanchion at the aisle so as to eliminate floor legs or pedestals.

Interior paneling should be such as to require no more than a swab with a damp cloth to keep clean and maintain the original finish. Windows should be made of nonglare, heat-resistant glass and be large enough to let passengers see where they are and where they are going. Lighting should be nonglare with individual spot lighting for reading. Aisles and step wells should have their own lights. Women complain of the lack of parcel space, so why not have folddown parcel racks for off-peak operation?

air conditioning and insulation

These are essential for summer bus riders. Space requirements for air conditioning have been a problem, but we have now in operation a new coach in which a system has been installed without affecting seating facilities or altering the outward appearance of the vehicle. The compressor is belt driven directly off the main powerplant, which eliminates the need for a separate diesel-engine drive. Heating requires better control and distribution than now customary.

noise reduction

Noise that bothers passengers at loading areas can be reduced by development of new injection and combustion principles, improving mufflers, developing greater engine thermal efficiencies, and doing a better job of insulation.

catering to driver

Power steering, automatic and simpler controls, improved brakes and vision are all items aimed at aiding the driver. We could suggest better methods of fare collection, now under the jurisdiction of the operator.

To Order Paper No. S153 . . .
. . . on which this article is based, turn to page 6.

STREAMLINES STRUCTURE — The Tube, Pipe, Hose and Lubrication Fittings Committee recently created seven standing subcommittees in an effort to speed report handling. Among those who discussed assignments at a recent meeting are (from left): George Rea, T. A. Campbell*, Carl Schaening*, J. L. Gowie*, Technical Board Sponsor E. C. Brown, TPHLFC Chairman Charles Wright, L. E. Manning*, T. E. Lyon, and William Hertel*. (Asterisk indicates newly appointed subcommittee chairmen.)

Technical Committee News . . .

CALIBRATION OF FUEL INJECTION PUMPS in field service will be simplified and more accurate when the equipment and procedure standardization recently undertaken by the Fuel Injection Equipment Subcommittee is completed. Shown with Subcommittee Chairman Robert Shallenberg, International Harvester's chief engineer for construction equipment injection systems, is Engine Committee Chm. J. L. Greathouse (right).

MARKINGS AND ROTATION OF TACHOMETERS are being standardized by the Speedometer and Tachometer Subcommittee of the Parts and Fittings Committee. Chatting with In-Coming Subcommittee Chairman R. O. Helgeby are R. P. Trowbridge, chairman of the Parts and Fittings Committee, and Former Subcommittee Chm. C. G. Davey.

THE RATING OF AUXILIARY BRAKES SUB-COMMITTEE was recently reactivated by the Brake Committee. Assuming the chairmanship and vice-chairmanship, respectively, are C. A. Carlson (left) and R. E. Kennel.

THE TRACTOR TECHNICAL COMMITTEE, in close cooperation with the Nebraska Tractor Test Board, has completed an extensive revision of the SAE Agricultural Tractor Test Code. Engrossed by the events at a recent meeting are 1958 Chm. I. F. MacRae (left) and In-Coming Chm. E. M. Brumbaugh.

INSTALLATION AND OPERATION OF MOBILE RADIOS will be covered in a manual being prepared by the Radio Communications Suitable for Automotive Fleet Applications Subcommittee. The manual will contain descriptions of the equipment used and maintenance required in addition to providing instructions for operation of the radio and base station. Chairman H. C. Baylis (center) is shown with subcommittee members George Mann (left) and Charles Hudson.

RECENT VEHICLE RADIO INTERFERENCE SUB-COMMITTEE TESTS show that today's cars and trucks can be suppressed to the interference limits established last year. At an Electrical Equipment Committee meeting are (from left): Past Chairman H. C. Doane, In-Coming Chairman G. H. Hostettler, and In-Coming Vice Chairman Brooks Short. Mr. Short is also chairman of the Vehicle Radio Interference Subcommittee.

About SAE Members

Nutt

Harder

Dybvig

Dodge

Schomburg

Gardner

Janeway

Ottmar

SAE PAST-PRESIDENT ARTHUR NUTT has retired as vice-president of engineering for Lycoming Division, AVCO Mfg. Corp. but will continue to serve Lycoming as a consultant. From 1930 to 1944, Dr. Nutt was a member of the Operating staff committee and vice-president of engineering of Wright Aeronautical Corp. In October, 1944, he resigned from Wright to become director of aircraft engineering for Packard Motor Car Co. From May 1949 to February 1951, Dr. Nutt conducted his own engineering and sales organization, Arthur Nutt and Associates. In February of 1951, he joined Lycoming Division.

D. S. HARDER has retired as vice-president and technical adviser to the president and chairman of the board of Ford Motor Co. Harder has set up an office at 1580 National Bank Building, Detroit 26, Mich. He joined Ford in 1946 as vice-president — operations, and within the next year became vice-president — manufacturing. He was elected executive vice-president — basic manufacturing division in January, 1955, and in April, 1958 was named to the position from which he is retiring.

C. C. DYBVIG has been elected vice-president-sales of Dana Corp. He joined Dana in 1954 as general sales manager. Before that he had been associated with Firestone Tire & Rubber Co. Dybvig was chairman of SAE Detroit Section for 1956–1957 and was 1958 chairman of the SAE Constitution Committee.

L. L. DODGE has been elected vice-president-administration of Dana Corp. He joined Dana in 1948 on special assignment to the president and in 1950 became executive assistant to the president. Before his election as vice-president, he was assistant general sales manager.

W. H. SCHOMBURG, JR., has been made assistant general sales manager of Dana Corp. to succeed L. L. Dodge. Since 1954 he has been product sales manager, universal joints only for Dana.

ROBERT S. GARDNER has been made vice-president of engineering and production of Wyle Research Corp. Formerly, he was vice-president and laboratory director for Wyle.

ROBERT N. JANEWAY, Detroit consulting engineer, has been made vice-president of engineering with Consolidated Foundries and Mfg. Corp. He will direct a new corporate product development program. Janeway will continue to head his own engineering firm, Janeway Engineering Co.

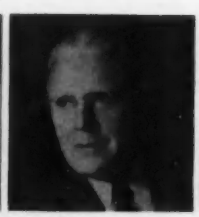
JEROME OTTMAR has been elected vice-president of Textron, Inc. of Providence, R. I., where he will be responsible for supervision of non-textile divisions. Ottmar previously was president of M. & C. Nuclear, Inc., Attleboro, Mass.

JOHN D. WILLIAMS has been made president of Lipe-Rollway Corp. and Rollway Bearing Co., Inc. He became director and vice-president of Lipe-Rollway in 1942. In 1953 he also became director and vice-president and general manager of Rollway Bearing Co. Williams succeeds **H. FOLLETT HODGKINS, SR.**, who has been made chairman of the board.

ROBERT M. ZIMMERMAN has been made vice-president of Lipe-Rollway Corp. He will continue in his capacity as general manager.

H. FOLLETT HODGKINS, JR., has been made vice-president of Rollway Bearing Co., Inc. He was formerly assistant to the general manager.

Williams



Hodgkins, Sr.

Allen

Wickham

Wright

Burns

ROBERT E. ALLEN has been made president of Precision Rubber Products Corp. He has been with the company since 1945. In 1949 he was appointed vice-president in charge of all sales. Allen was then made vice-president of the company.

HULL WICKHAM has been made vice-president of engineering and maintenance of Frederick B. Ayer & Associates, Inc. Wickham was founder and former president of Mattituck Air Base Corp.

ALEXANDER M. WRIGHT has been named vice-president of engineering of the newly incorporated Chandler-Evans Corp. Prior to this, he has been chief engineer for the same company.

LOUIS G. BURNS has been named vice-president of sales of Chandler-Evans Corp. Prior to this, he was sales manager for the same company.

JOHN T. RAUSCH has been made assistant chief engineer in charge of AC's motor group of products with AC Spark Plug, division of General Motors Corp. Formerly, he was staff engineer for Chevrolet Motor Division, GMC.

DONALD H. McPHERSON has been made staff engineer in charge of engine design at Chevrolet Motor Division, GMC. Formerly, he was assistant staff engineer for Chevrolet Motor Division, GMC.

JACK M. CHERNE has become director of engineering with Vard, Inc. Prior to this, he was project engineer for the Aircraft Division of Hughes Tool Co.

ERNEST H. SCHANZLIN is now chief engineer with Tuthill Co. He will direct all of Tuthill's research and engineering activities. Schanzlin was formerly assistant to the director of engineering for Pesco Products Division, Borg Warner Corp.

HAROLD E. BARNUM has been made assistant manager of the Foundry Division, Vanadium Corp. His responsibilities will include both iron and steel foundry activities of the corporation. Formerly, he was metallurgical engineer for the same company.

ERNEST J. WILLSON has become engineering manager, Fuel Injection Division of Hartford Machine Screw Co. Formerly, he was a development engineer in charge of the development section for the same company.

THOMAS D. HESS has been made chief development engineer of Hartford Machine Screw Co. Formerly, he was a field engineer for the same company.

RUSSELL R. VOUGHT has been made president of Vought Co. of Beverly Hills, Calif. For the past 35 years he has been an executive of Chance Vought Corp., and subsequently a director, vice-president, and west coast general manager for United Aircraft Service Corp.

GEORGE A. STAUFFER has been made chairman of the board of Thompson Products, Ltd. He was formerly president of Thompson Products, Ltd.

The following SAE members were prize winners in a "case histories" contest held by Douglas Aircraft Co., El Segundo, Calif.: **FRANCIS J. MARKEY**, Moraine Products Division, General Motors Corp.; **JOHN CORY**, Chrysler Corp.; **DONALD JESSE MATHIAS**, Convair Division, General Dynamics Corp.; **ROBERT R. BRIDGMAN**, K. R. Wilson, Inc.; **GEORGE M. BATEMAN, JR.**, Standard Pressed Steel Co.; **ROBERT E. SCHMITT**, Thompson Ramo Wooldridge, Inc.; **RICHARD S. KOPCHYNSKI**, Air-Maze Corp.; **CONRAD TEICHERT, JR.**, Lear, Inc.; **ROY O. ERICKSON**, P&H Diesel Division, Harnischfeger Corp.

VICTOR F. MASSA was the guest speaker at a meeting of the Metropolitan Section of the Mercedes-Benz Club of America held January 17 at Two Bridges Inn, Lincoln Park, N. J. Massa, a research engineer with Esso Research and Engineering Co., Linden, N. J., spoke on "What Makes Your Car Run."

STANFORD R. OVSHINSKY has become president of Ovitron Corp. Prior to this, he was president of General Automation, Inc.

WALTER E. FROEHLICH has become vice-president — engineering at Associated Spring Corp. He joined the Wallace Baines Division of Associated Spring in 1935, later becoming general manager of the division. He was elected a director of Associated Spring in 1953 and in 1955 became a vice-president. Before his new appointment, he served as vice-president — marketing and research and development.

CHESTER C. PEARSON has been made assistant director of manufacturing, Missile Systems Division of Lockheed Aircraft Corp. He was formerly vice-president of manufacturing for Beech Aircraft Corp.

GEORGE H. MOORE is now working toward an MBA degree at the Graduate School of Business, Stanford University. He was formerly project engineer for the engine engineering department, Ford Motor Co.

DANIEL A. DAMM is now vice-president in charge of operations with Schultz Die Casting Co. Prior to this, he was quality control engineer for the same company.

WILLIAM O. MURTAGH is now sales manager and secretary with Schultz Die Casting Co. Prior to this, he was manager of merchandising Division for Hoover Ball & Bearing Co.

JAMES G. MORRISON has been named sales manager–Central area, with headquarters in Chicago with U.S. Steel Corp. Formerly, he was manager of sales for National Tube Division for the same company.

STEPHEN P. CUFF is now an applications engineer with Donner Scientific Co. Formerly, he was technical sales analyst for Sikorsky Aircraft Division, United Aircraft Corp.

JOSEPH M. TUCKER has been made director of product planning at New Holland Machine Division, Sperry-Rand Corp. Formerly, he was president and general manager for Thomas Hydraulic Speed Controls, Inc.

continued on next page

Rausch | Cherne | Schanzlin | Barnum | Willson | Hess

SAE Members Say:

Automatic Control Devices No Substitute for Human Mind

— says Charles A. Chayne, General Motors' vice-president of engineering.

Substantial further progress in the contributions of vehicle design to highway safety can be confidently expected, says Charles A. Chayne in his recently published booklet, "Automotive Design Contributions to Highway Safety" Chayne contends:

"The control of an automobile involves three distinct operations — perception, decision, and action. Many aids — and even some substitutes — have been developed for the perception and action functions of the driver, but it is much more difficult to substitute devices for the human mind in the decision-making area.

"Moreover, no device warrants adoption as a substitute for human action unless its rate of failure is superior to that of the average driver. In the present state of electronics development, it is not possible to provide automatic car control devices that would meet this requirement."

HERBERT D. SMITH has been made general sales manager of U.S. Tires Division, United States Rubber Co. He will be responsible for replacement sales of U.S. Royal tires and other automotive products of the division. Formerly, he was director of automotive sales for U.S. Rubber.

CHARLES B. GROVE has been made general manager of market development, Industrial Division of Armstrong Cork Co. Formerly, he was manager of gasket and packing sales for the same company.

DR. RALPH A. SCHAEFER has been made director of a newly organized research and development department of Bunting Brass and Bronze Co. He was formerly technical adviser to the president for Cleveland Graphite Bronze Division, Clevite Corp.

ZOLLY C. VAN SCHWARTZ has been made technical consultant with C. A. Norgren Co. Formerly, he was director of engineering standards for Baldwin-Lima-Hamilton Corp.

RALPH W. GOETZ has been made sales manager, United Specialties Division of Industrial Enterprises, Inc. Formerly, he was production supervisor for Chicago Screw Co., Division of Standard Screw Co.

FREDERICK K. BLOOM has become manager of the research laboratory at Baltimore Works, Armco Steel Corp. Formerly, he was supervising research metallurgist for Armco.

ALFRED H. PATON has been made executive vice-president, Standard Products group of Dominion Engineering. He is 1958–59 vice-chairman of SAE Montreal Section. Formerly, he was chief engineer for the same company.

RICHARD C. KEANE has been named manager — all product sales with American Bosch Division, American Bosch Arma Corp. He will be responsible for sales activities on all products of a non-military nature, both for original equipment to manufacturers and for the after-market. He was previously manager of manufacturer's sales for the same company.

THURMAN F. NAYLOR has become sales manager with Metal Products Division of Koppers Co., Inc. He will have direct responsibility for district sales operations, development and administration of training programs for sales personnel, agents, and distributors, and the direction of contract sales. Naylor was formerly assistant sales manager for Koppers.

WILLIAM M. KISSAM has been made trucking supervisor in the operations section at Tidewater Oil Co.'s eastern division marketing department. Formerly, he was automotive equipment and research engineer for the same company.

ROBERT S. LEE has become manager of passenger tire construction with Firestone Tire & Rubber Co. Prior to this, he was project engineer for Firestone.

Schaefer

Van Schwartz

Bloom

Naylor

Smith

Grove

Goetz

Keane

Kissam

Lee

LOVELL SHOCKEY has been made sales manager with Cleveland Works of National Malleable and Steel Castings Co. He has been development engineer of the Industrial Division since joining National Malleable in 1956. Shockey succeeds **DONALD L. GRIFFITH,** who will become sales coordinator and will be assigned to follow expansion programs.

W. W. CHURCHILL is now superintendent of equipment and maintenance with Coast-Lee & Eastes, Inc. Formerly, he was regional manager for Western Greyhound Lines.

HOWARD W. CHRISTENSON has been named to head the expanded research department of the transmission engineering department at Allison Division of General Motors Corp. He was formerly chief development engineer. **ROBERT M. TUCK** is succeeding Christenson as chief development engineer of the transmission engineering department. Formerly, he was development engineer.

EDWIN L. ALLEN has been made chief research engineer — automotive with Atwood Vacuum Machine Co. For the last 20 years he has been an executive engineer for Schonitzer Engineering Co.

JOHN B. WHITE has been named plant manager at Pittsburgh Plate Glass Co.'s Cumberland, Md., plant. Formerly, he was assistant manager for the company.

GEORGE E. ROWBOTHAM is now a standards engineer with Teleflex, Inc. Prior to this, he was engineering manager for Cone Automatic Machine Co.

ELMER E. LITTON is now automotive and industrial engineer with Richfield Oil Corp. Formerly, he was an automotive engineer for M.F.A. Oil Co.

DR. AUGUSTUS B. KINZEL, vice-president of research, Union Carbide Corp., was elected vice-president of Engineers Joint Council.

K. D. SMITH, vice-president of National-Standard Co., has been appointed special adviser on the rubber industry for the company.

P. W. GODARD is now owner of Wand Rubber Stamp Works. Formerly, he was industrial products representative for Shell Oil Co.

ROBERT E. REICHARD is now an associate engineer with Douglas Aircraft Co., Inc. Prior to this, he was a junior engineer for Bendix Products Division, Bendix Aviation Corp.

Cartwright Receives 1958 Springer Award

B. W. Cartwright (right) is presented with the 1958 Russell S. Springer Award plaque by Detroit Section Chairman W. E. Burnett at the Section's December 8 meeting.

BERT W. CARTWRIGHT, assistant managing engineer of Chrysler's transmission group, has received the 1958 Russell S. Springer Award for being the youngest member of SAE to have a technical paper published in the 1958 Transactions. Cartwright's paper was entitled "The Chrysler Torque Flite Transmission."

Born in 1928, Cartwright attended Wayne State University and Chrysler Institute of Engineering. He has been with the advanced transmission design department since 1950.

SAE Booth at Fifth World Petroleum Congress

ENGINEERS from abroad will have an opportunity to learn about SAE and its services during the Fifth World Petroleum Congress, May 31 to June 5, 1959, at The Coliseum in New York City.

During the Congress SAE literature will be displayed at a booth, manned by SAE members associated with the petroleum industry.

The Society's Fuels and Lubricants Activity is organizing SAE's participation, and Activity Member A. L. Brodie of the Texas Co. is already lining up members to staff the booth on half-day shifts.

Scientists and technologists from 27 countries will present 285 papers on major technical developments and problems facing the petroleum industry. These reports, to be presented in either French or English, represent the largest number ever given before the World Petroleum Congress.

Another important feature of the Congress will be an exposition of the latest developments in equipment being manufactured for the oil industry.

At the 1959 New York Aeronautic Meeting . . .

. . . 27 technical programs will provide a depth coverage on subjects from Cost Reduction to High Energy Fuels, at the Hotel Commodore in New York, March 31-April 3.

R. W. Middlewood
Chairman
Design Engineering and Air Transport Group
Meeting Planning Committee

K. W. Stalker
Chairman
Production Engineering Group
Meeting Planning Committee

THROUGHOUT the four days of 1959 SAE Aeronautic Meeting, aeronautical production men, propulsion engineers, air transport specialists, and flight vehicle engineers will have sessions available in their specific area of technical interest.

Production and Manufacturing

The Production Engineering Group of the Meeting Planning Committee, under the leadership of K. W. Stalker (Aircraft Gas Turbine Division, General Electric Co.) has finalized plans for eight programs tailored to the needs of production specialists. Full-day panel discussions on **Fabricating Ultra High Strength and Refractory Materials, Cost Reduction, Guidance and Control,** and **Product Reliability** are scheduled for Tuesday, March 31. A unique feature of these panels is the presentation of prepared papers that will bring into focus the major manufacturing problems or describe methods employed in solving troubles. The papers will be available as preprints and will be a point of departure for discussion by the panels and audiences.

Additional panels and sessions are programmed for production men on Wednesday, April 1. Discussion of the design, manufacture, and use of **Ground Support Equipment**; a review of both economic considerations and the effects of government policies in determing whether to **Make or Buy**; news of latest development and case histories illustrating successful handling of **Numerical Controlled Machine Tools** will be the subjects of three half-day panels. A technical session, **Looking Ten Years Ahead in Manufacturing,** will project new processes of stock removal, fastening and shaping by plastic deformation.

Nineteen sessions have been developed by the Design Engineering and Air Transport Group of the Meeting Planning Committee, under the chairmanship of R. W. Middlewood (Georgia Nuclear Laboratories, Lockheed Aircraft Corp.).

Air Transportation

For Air Transport specialists, there will be technical sessions on Tuesday, March 31, and on Thursday and Friday, April 2 and 3. Tuesday's features will include design and operation conderations of **Turbine Fuels** and **Starting and Servicing Equipment for Turbine Transports.** On Thursday morning, acoustic, thrust, and drag characteristics together with design, development, and operational experience of **Sound Suppressors and Jet Reverses** will be discussed. During the afternoon, three papers will review **Collision Prevention and Air Traffic Control.** Friday will highlight **Landing and Take-Off Performance** considering SR-422A, problems encountered, and methods of im-

Summary Program of 1959 SAE Aeronautic Meeting

	Tuesday, March 31	Wednesday, April 1	Thursday, April 2	Friday, April 3
MORNING	Fabricating Ultra High Strength Materials Cost Reduction Guidance and Control Product Reliability Turbine Fuels	Ground Support Equipment Make or Buy Numerical Controlled Machine Tools Turbine Engines High Temperature Resilient Seals	Ramjet and High-Energy Fuels—Closed High-Strength, High-Temperature Structures Sound Suppressors and Jet Reversers	Rockets and Propellants Landing and Take-Off Performance Manned Vs. Unmanned Flight Vehicles
AFTERNOON	Fabricating Ultra High Strength Materials Cost Reduction Guidance and Control Product Reliability Starting and Servicing Equipment for Turbine Transports	Looking Ahead in Manufacturing Human Engineering Applied to Weapons and Aircraft Auxiliary Powerplants for High-Speed, High-Altitude Aircraft Missiles Propulsion and Cooling	Rockets and Propellants—Closed Collision Prevention and Air Traffic Control	Airline Experience with New Turbine Transports Space Propulsion VTOL Aircraft Powerplant Requirements
EVE		High-Energy Fuels	DINNER	

provement. A series of reports on **Airline Experience with New Turbine Transports** will be presented later in the day.

Propulsion Engineering

Propulsion engineers will desire to attend the April 1 morning program, that will include discussion of design approaches, anti-icing and reliability of **Turbine Engines.** In the afternoon, **Auxiliary Powerplants for High-Speed, High-Altitude Aircraft** program will augment a session dealing with **Missiles Propulsion and Cooling.** A special evening program has been planned on **High-Energy Fuels** at which engineers will learn more about pyrophorics, high performance hydrocarbon fuels, and solid propellants.

Trends in storable propellants, development problems with large cryogenic systems, and thrust magnitude control of soil propellant rocket motors, will be included in the Friday morning **Rockets and Propellants session.** Two afternoon programs will deal with nuclear and electric **Space Propulsion** and **VTOL Aircraft Powerplant Requirements.**

Flight Vehicle Design

The flight vehicle design and project engineers will find several technical programs of interest to them. On Wednesday, April 1, a highlight will be five papers dealing with **High Temperature Resilient Seals.** That afternoon, **Human Engineering Applied to Weapons and Aircraft** shall be discussed.

The High-Strength, High-Temperature Structures program on Thursday will include description of research work performed, refractory nonmetals for hypersonic aircraft, and the developments of refractory sheet metal structures.

Friday morning presents the opportunity to hear discussions on the comparative cost and effectiveness of manned aircraft and guided missiles, together with the role of manned systems at the **Manned versus Unmanned Flight Vehicles** session.

Aircraft and Missile Engineering Display

Graphically augmenting the discussions of the panels and technical sessions, will be the 66 booth **Aircraft and Missiles Engineering Display.** Available for review will be such items as new sound suppressors, high temperature materials, turbine fuel filters, solid propellant rockets, high temperature resilient seals, ramjets, and ground support equipment.

You'll . . .

. . . Be interested to know

BRIDGING THE GAP between science and engineering for SAE members has been the main concern of the Science-Engineering Advisory Committee, Chairman L. R. Hafstad reported to SAE Council in January.

To this end, the Committee has chosen measurements — the common denominator in all phases of engineering — as one of the best means of gap-bridging. . . . Companies doing basic research and development in the broad area of transportation are being encouraged to use SAE existing channels for dissemination of results.

SAE SUMMER MEETING IN 1960 will be held at the Edgewater Beach Hotel in Chicago . . . and social activities will be subordinated to the technical aspects of the gathering. SAE Council made this determination at its January meeting by approving specific recommendations made by the SAE Meetings Committee following a 12 month study.

The Meetings Committee's consideration of this important question brought into focus the thinking of every Activity Committee, as well as of their vice-chairmen for meetings who comprise the Meetings Committee itself. Round-table discussions, questionnaires, and various other means were used to get clear the thoughts of all concerned. The focus was made by a special subcommittee of the Meetings Committee headed by S. J. Tompkins. Serving with him were Anderson Ashburn, Gregory Flynn, Jr., and F. P. Steiner.

PAST-PRESIDENT W. K. CRESON has agreed to continue his vigorous support of SAE's student activities by acting as special adviser to the 1959 Student Committee chairman. With 56 SAE Student Branches now in full swing — and four informal Clubs working toward student branch status — 1959 should be a banner year in student activities.

THE COMPUTER as a day-to-day problem solver is one of the subjects under study by the Electronic Computer Advisory Committee, its Chairman Ralph E. Cross reports. Specific uses of computers in SAE's technical areas — case histories, as it were — will be explored and the results presented to SAE members.

Serving with Chairman Cross on this Committee are: S. N. Alexander, National Bureau of Standards; Harry H. Goode, Bendix Aviation Corp.; Donald E. Hart, General Motors-Research; John L. Jones, Chrysler Corp.; Robert A. Roggenbuck, Ford Motor-Research.

PLANS FOR SAE PARTICIPATION in the 1959 Nuclear Congress are well under way. A number of papers are available for SAE sponsorship, and or-

ganization of a reader's committee for their evaluation is the task of T. F. Nagey, SAE's representative on the Nuclear Congress Program Committee.

CHAIRMAN FRANK W. FINK, Missiles Advisory Committee, points to the 45 papers on missiles topics — given before three SAE National Meetings in the past 12 months — as evidence of the sound program sponsored by his Committee. In addition, he says, four Missile Newsletters were distributed to all SAE Sections.

Planned as part of the 1959 program are sessions at the New York and Los Angeles National Aeronautic Meetings, and at the 1960 Annual Meeting in Detroit.

R. E. SPOKES, American Brake Shoe Co., has been appointed SAE liaison representative with the Society of Plastics Engineers. He will serve on an SPE Inter-Society Liaison Committee established by SPE to consider areas of mutual interest to SAE and SPE.

ONTARIO SECTION is the new name of the 30 year old Canadian Section. Council authorized the requested change at its January meeting, noting its appropriateness because there are now three SAE Sections and one SAE Group functioning actively in Canada. . . .

CHICAGO SECTION has had the county of Elkhart, Indiana, added to its territory. Most of the County members reside in Elkhart City — just 15 miles from South Bend where Chicago Section's South Bend Division holds its monthly meetings. . . .

CONSTANT INCREASES in the number of technical reports covered in SAE Handbook — from 240 in 1951 to 365 in 1959 — is "documentary" of the Technical Board's expanded services to the ground and air industries, Technical Board Chairman O. K. Kelley reported to SAE Council at its January meeting.

Among recent accomplishments in the ground vehicle area is a new Recommmended Practice for 12-Volt Lamp Bulbs and Sealed Units for Heavy-duty Brake Fluid with a Minimum Boiling Point of 375 deg. F.

In the aeronautical-space field, the Society has expanded its technical committee service to include the needs of rocket and missile manufacturers. A special Aeronautical Specifications Group was established to cover rocket and missile material, specifically. An increasing number of technical reports and standards are being developed for rocket component technical requirements, such as a document to spell out performance requirements for missile hydraulic pumps.

Federal and State agencies are looking increasingly to SAE for establishment of minimum technical requirements for reference in determining vehicle regulations.

THE OVERSEAS INFORMATION COMMITTEE, through its Chairman, M. A. Thorne, reports that SAE Journal readers were treated to 65 pages of overseas material during 1958. Interesting automotive developments in England, France, Russia, Germany, Holland, Sweden, and Japan provided the subjects, which ranged from European steel manufacturing and quantity production methods to design features of a typical Japanese truck engine. His Committee, he says, was responsible for most of this coverage — and, in addition, was privileged to assist in obtaining several meeting papers on overseas subjects.

As many as three sessions at 1959 Summer Meeting may be devoted exclusively to overseas technical developments, Chairman Thorne says. Sessions would be made up of paper presentations from a selected group of visiting foreign engineers — one session to take the form of a panel of five or six European manufacturing engineers or executives who will answer questions from the floor.

SAE National Meetings

- **March 31-April 3**

  National Aeronautic Meeting (including production forum and engineering display), Hotel Commodore, New York, N. Y.

- **June 14-19**

  Summer Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

- **August 10-13**

  International West Coast Meeting, Hotel Georgia, Vancouver, B. C., Canada

- **September 14-17**

  National Farm, Construction, and Industrial Machinery Meeting (including production forum and engineering display), Milwaukee Auditorium, Milwaukee, Wis.

- **October 5-10**

  National Aeronautic Meeting (including manufacturing forum and engineering display), The Ambassador, Los Angeles, Calif.

- **October 26-28**

  National Transportation Meeting, La Salle Hotel, Chicago, Ill.

- **October 27-28**

  National Diesel Engine Meeting, La Salle Hotel, Chicago, Ill.

- **October 28-30**

  National Fuels and Lubricants Meeting, La Salle Hotel, Chicago, Ill.

SAE charters

2 new student branches

In canada . . .

Faculty Advisor O. L. Symes

Enrolled Students at the newly chartered SAE Student Branch at the **University of Saskatchewan** have an opportunity to visually inspect topics discussed at their meetings — the success of which is evidenced by the fact that the first meeting, after receipt of a charter, drew the largest attendance.

Programs to maintain high interest are being planned by **Faculty Advisor O. L. Symes**, associate professor of agricultural engineering; Student Branch Chairman **Byran Stolee**; Chairman-Elect **Murray Swanston**; Secretary **Grant McCarthy**; and Treasurer **Don Smith.**

SAE activities on a large-scale include the building of a "Cyclops" to be displayed at a College of Engineering student show . . . special meeting speakers include A. O. Lepine, district manager of Perfect Circle Corp., Ltd., who discussed manufacturing techniques, installation, and service maintenance of piston rings. Tours of engine rebuilding plants of Bowman Bros., Ltd., and of the local RCAF Station, round out the year's activities for the new SAE Student Branch.

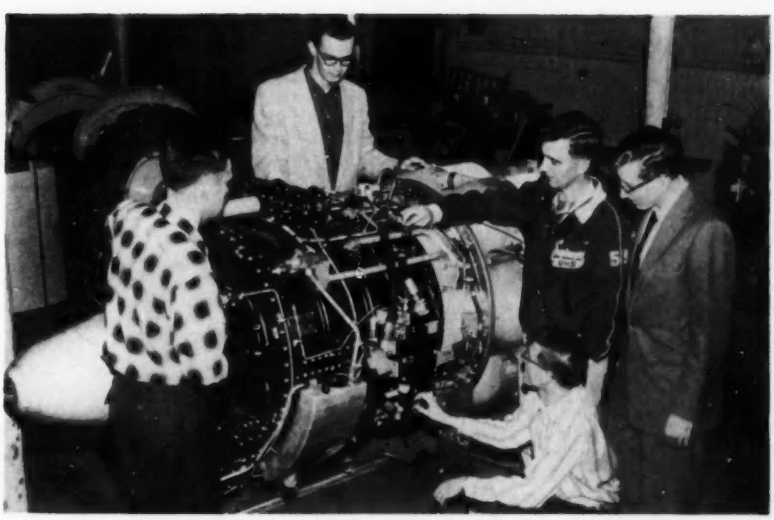
The University of Saskatchewan is situated near the South Saskatchewan River in Saskatoon, and is among the smallest universities in Canada — enrollment of about 4,100 this year marks an all-time high in the University's history.

At marquette university . . .

SAE's new Student Branch at the **University of Marquette** received its SAE charter in the year marking the golden anniversary of the University's College of Engineering. One or two meetings are usually held each month — one during the day, and one at night — thereby accommodating cooperative-program students and night-school Enrolled Students.

The Branch was first organized by a small nucleus who realized the potential of such a society in the College of Engineering. Principals included Assistant Professor **Robert E. Harloff**, Milwaukee Section Student Chairman **F. B. Esty**, Frank Spexarth, Dick Rademacher, Bob Browning, Bob Lohse, Carl Schmidt, Tom Olk, and Stuart McComas. Today's officers are Chairman **Thomas Kuczkowski**; Vice-Chairman **Paul Haas**; Secretary **Kevin Carey**; and Treasurer **Ken Mettelmann.** The faculty advisor is Professor Harloff.

The Marquette SAE Student Branch encourages members of civil, electrical, and mechanical engineering to investigate the organization — and appeals to student's interest whether in background, design, production or maintenance of various products of the automotive and aircraft industries. For these reasons, when no technical speaker is scheduled for a meeting, movies on automotive and aeronautical subjects, practical engineering, and general interest are shown.



Five members of the SAE Student Branch at the University of Saskatchewan look over an Orenda jet engine. The engine was one item they saw during a recent tour of the local RCAF station. Standing around the engine (left to right) are: Don Smith, treasurer of the Student Branch; Byron Stolee, Student Branch chairman; Grant McCarthy, secretary; and SAE Enrolled Student John Richert. Bob Beveridge, Enrolled Student, is kneeling in the foreground.

Rambling . . . THROUGH THE SECTIONS

Future designers of machine tools will have to gear their designs for easy interpretation into numerical quantities . . . since future machine tools will be controlled by digital computers. According also to John L. Hill at **TWIN CITY SECTION** in January, low cost machines can reproduce parts by memorizing movements of the cutting tool along the machine's three axes — while under the control of an expert machinist. (Hill, director of research and development, Ramsey Engineering Co., is shown above explaining slides that accompanied his talk, "Numerical Control of Machine Tools.")

• • •

"Flying platform" missions, planned by the Army if development proves successful, are threefold: (1) Transporter and gun-firing platform for front line use; (2) Electronics platform to overcome the obstacle of line-of-sight radio transmission; and (3) General-purpose utility vehicle similar to the land based vehicle.

Flying platforms are now under development by Chrysler, Piasecki, and Aerophysics Corp. . . . a trio chosen from 21 firms which made 27 proposals. The flight platforms have a 25 knot speed, 25 nautical mile range, can be carried in groups of four in a C-130 transport, and have a payload of about 1000 lb.

Powerplants for the aerial vehicles — 250-hp turbines coupled to provide a 500-hp unit — are now under development by GMC's Allison Division. With Allison's $7,000 price tag — **cost of an aerial platform might be as much as $25,000–$30,000.**

(Larry Hewin, chief of Aviation for the Army's Research and Engineering Command, Fort Eustis, Va., at **WASHINGTON SECTION.**)

First satellite terminal's living quarters might be in a large wheel structure revolving around one end of the space vehicle's core — generating synthetic gravitational force in the otherwise weightless space state . . . envisioned Aerophysicist D. C. Romick.

The terminal's framework, erected around the core, would house all equipment such as power generators, air conditioners, storage space, repair and servicing shops, and research laboratories.

Romick reported to **WICHITA SECTION** that, although the original terminal would be relatively small, it could be expanded to perhaps 500 ft in diameter and 1,500 ft in length. With these large quarters, as many as 5,000 technicians, observers, visitors, and other personnel could move between living quarters and work areas, via cars which also serve as air locks.

Romick is assigned to guide missile research at Goodyear Aircraft Corp. He spoke to a joint meeting of the Wichita Section and the Women's Aeronautical Association of Kansas.

Romick, center, discusses his research work with Mrs. J. W. Massey, president of the Women's Aeronautical Association of Kansas, and Virgil Adamson, (right), chairman of the Wichita Section.

Average passenger car horsepower has more than doubled in the past 11 years, and still shows no sign of leveling off . . . according to E. M. Johnson of Texaco Research. There has been a corresponding increase in torque, in the use of V-8 engines, in compression ratios, and in engine speeds, and about 30% increase of displacement. Johnson spoke in January to a joint meeting of **SAE CLEVELAND SECTION** and ASLE.

Foreign visitors in attendance were Roel Van Der Valk (left), and John M. Vercruysse (right), both of the Vredestein organization, Enschede, The Netherlands. Center is their host, William H. Denton of the B. F. Goodrich Co.

• • •

BUFFALO SECTION has prepared a "Who's Who" of past-section chairmen — with names, addresses, and brief biographical sketches, from 1924 to date.

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29 Sections were represented by 51 members attending the Sections Committee luncheon at the 1959 Annual Meeting. **Southern California Section Chairman Brent Malin** spoke to the group on the application of industry methods to Section organization and operation.

Changes in bus designs seem essential if city transit systems are to meet private car competition. Suggested changes include large curved windows, three double doors, wider over-all dimensions, 39 seats instead of the current 50, and improved insulation, noise reduction, and driver-mechanisms.

These and other developments in bus transportation were discussed in December at **PHILADELPHIA SECTION** by G. E. Mintz, chief engineer, Bus Division, Mack Truck Co., and E. N. Hatch, director, Bureau of Franchises, Nassau County, L.I., N.Y.

Seated at the speaker's table were, (left to right), R. A. Winemiller, Section vice-chairman, Truck and Bus Activity; F. J. Woechan, Section vice-chairman, Transportation and Maintenance Activity; Speaker G. E. Mintz; A. H. Glazenapp, technical chairman for the meeting; Speaker E. N. Hatch; and Josiah French, Section Chairman.

This highly successful meeting was the Section's **first session in their Allentown area** . . . with 90 engineers attending an afternoon tour of the assembly lines of Mack Truck Co., and 150 attending the evening social hour, dinner, and technical session.

AN OPTION . . .

"Any member residing outside Section territory, upon written request for assignment to membership in a given Section may be so assigned.

"Such a member can select only one Section."

The above information (pertinent to about 5% of SAE members who live outside Section or Group territory) is printed at the request of SAE Council.

Request for assignment to a specific Section or Group should be addressed to Sections Department at SAE Headquarters.

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At Ecole Polytechnic in Montreal, 117 students applied and received SAE Enrolled Student status in January alone. **MONTREAL SECTION'S** Governing Board has been meeting with the newly formed group to help with their proposed constitution. . . .

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Special seminar series on Anti-Friction Bearings is being sponsored by the **SOUTHERN NEW ENGLAND SECTION** in March. Five sessions will be held during the month, starting March 3. The fee is $4.00 to non-members and $2.00 to members . . . meetings will be held at The Hartford Graduate Center in East Windsor Hill, Conn.

DETROIT SECTION again welcomes all papers eligible for their Henry Ford Memorial Award. Each year this award is presented for the best paper on a subject relating to automotive ground vehicles . . . written by a SAE member (regardless of membership grade) under 33 years of age at the time his paper is submitted in the competition.

Originality, significance of subject and conclusions, extent of research, logical organization, and clarity of writing are among the important considerations of the Award Committee.

Papers submitted need not have been presented at SAE meetings, but should be of acceptable standard for presentation at any national or Section meeting.

The Award Committee will consider any paper presented, or submitted, during the Detroit Section year of June 1 to May 31. This year's award carries a cash value of $200.

Interested members may secure copies of the Award booklet, or further information, by writing the Henry Ford Memorial Award Committee, Detroit Section SAE, Rackham Building, 100 Farnsworth, Detroit 2, Mich.

A massive and coordinated attack on interplanetary travel will be dependent on the development of nuclear-powered propulsion systems . . . reported T. F. Nagey at **INDIANA SECTION**, in his paper on "Nuclear Rocket Propulsion — A Survey of Proposed Concepts."

Pre-meeting discussion with the speaker included, left to right, Section Chairman W. M. Horner; N. Dienhart; Nagey, director of research, GMC's Allison Division; Section Aircraft Vice-Chairman D. D. DonCarlos; and C. E. Mines, chief, engineering services, Allison Division.

SAE Section Meetings—

ALBERTA

April 17 . . . Factory representative, Champion Spark Plug Co. "Plugs for All Uses." Empress Hotel, Calgary. Dinner 6:30 p.m. Meeting 7:00 p.m.

BALTIMORE

April 9 . . . SAE President Leonard Raymond, special guest.

BRITISH COLUMBIA

March 26 . . . Joint meeting SAE and Canadian Aeronautical Industry. D. J. Caple, sales engineering manager, Orenda Engine Co., Ltd. "Iroquois Turbine Engine as Used in the Avro Arrow Aircraft." Hotel Georgia, Vancouver.

April 20 . . . J. Brent Malin, manager, Additives, Western Region, E. I. du Pont de Nemours, Inc. "Abnormal Combustion Phenonema in High Compression Engines." Hotel Georgia, Vancouver.

BUFFALO

April 6 . . . Bill Hackman, automotive editor, Rochester Democrat & Chronicle. "The Foreign Car." Wishing Well, 1190 Chili Ave., Rochester. Dinner 7:00 p.m. Meeting 8:00 p.m.

April 21 . . . Fred Maxam, Boeing Transport. "Commercial Jet Airliners." Hotel Sheraton, Buffalo. Dinner 7:00 p.m. Meeting 8:00 p.m.

CINCINNATI

April 27 . . . Bert Harris, engineer, White Motor Co. "Plastic Truck Cabs & Applications." Engineering Society of Cincinnati, McMillan at Woodburn. Dinner 6:30 p.m. Meeting 8:00 p.m.

CLEVELAND

April 14 . . . Akron-Canton Meeting. Victor P. Kovacik and Daniel P. Ross, Thompson - Ramo - Wooldridge, Inc. "Performance of Nuclear Electric Propulsion Systems." Hotel Sheraton-Mayflower, Akron.

DETROIT

April 6 . . . Junior Activity Meeting. "The Engineer in Management." Rackham Educational Memorial. Dinner 6:30 p.m. Meeting 8:00 p.m.

April 13 . . . Regional Activity Meeting. Dr. Kenneth McFarland. "3 Dimensional Confidence." Hotel Commodore Perry, Toledo.

METROPOLITAN

April 23 . . . P. H. Cerf, executive vice president, Cerlist Diesel, Inc. "Cerlist Two-Cycle Looped Scavenged Three Cylinder Engine." Henry Hudson Hotel, 57th St. and 9th Ave., New York City. Meeting 7:45 p.m.

MILWAUKEE

April 3 . . . Carl Silver, senior project scientist, Aero Division, Minneapolis-Honeywell Regulator Co. "The Human Factors In Space Flight." Milwaukee Athletic Club. Dinner 6:30 p.m. Meeting 8:00 p.m.

MONTREAL

April 20 . . . "Vertical Take-Off and Landing." Speaker will be chief engineer, Rolls-Royce, Ltd. Sheraton-Mount Royal Hotel. Dinner 7:00 p.m. Meeting 8:00 p.m. Special Feature: Reception 6:15 p.m.

NORTHWEST

April 17 . . . J. Brent Malin, manager, Additives, Western Region, E. I. du Pont de Nemours, Inc. "Abnormal Combustion Phenomena in High Compression Engines." Stewart Hotel, 2nd and Stewart St., Seattle. Dinner 7:00 p.m. Meeting 8:00 p.m.

ONTARIO

April 17 . . . Dr. W. B. Dymond, minister of health, Province of Ontario. "Highway Safety." Hotel Prince Edward, Windsor. Dinner 7:00 p.m. Meeting 8:00 p.m.

PHILADELPHIA

April 8 . . . SAE President Leonard Raymond. "How Tomorrow's Problems Challenge Today's Research." The Engineer's Club, 1317 Spruce St. Cocktails 6:00 p.m. Dinner 6:30 p.m. Meeting 7:45 p.m.

PITTSBURGH

April 28 . . . O. J. Schwarm, director, guidance & child accounting, Pittsburgh Public Schools. "Education & Training for Engineering." Mellon Institute, Fifth Ave. Dinner 6:30 p.m. Meeting 8:00 p.m. Special Feature: Student Speaker Competition.

ST. LOUIS

April 14 . . . A. Heintze, consulting engineer, and a panel of experts. "Stump the Experts." Ambassador Kingsway Hotel, 108 N. Kings Highway. Dinner 7:00 p.m. Meting 8:00 p.m.

SPOKANE-INTERMOUNTAIN

April 22 . . . J. Brent Malin, manager, Additives, Western Region, E. I. du Pont de Nemours, Inc. "Abnormal Combustion Phenomena in High Compression Engines." Desert Caravan Inn, Spokane. Dinner 7:00 p.m. Meeting 8:00 p.m.

VIRGINIA

April 22 . . . SAE President Leonard Raymond. "How Tomorrow's Problems Challenge Today's Research." Hotel William Byrd, Richmond. Social Hour 6:30 p.m. Dinner 7:00 p.m. Meeting 8:00 p.m.

WASHINGTON

April 21 . . . SAE President Leonard Raymond to deliver Presidential Address. Principal speaker will be Charles Daniels, assistant chief engineer, All American Engineering Co. "U.S.M.C. Use of Short Field Catapults & Arresting Gear." Occidental Restaurant, Pennsylvania Ave. at 14th St. Dinner 7:00 p.m. Meeting 8:00 p.m.

WILLIAMSPORT

April 6 . . . SAE President Leonard Raymond. "How Tomorrow's Problems Challenge Today's Research." Moose Hall Auditorium, East 3rd St. Dinner 6:45 p.m. Meeting 8:00 p.m.

sae central illinois section's 10th annual

EARTHMOVING INDUSTRY CONFERENCE

APRIL 14–15, 1959
PERE MARQUETTE HOTEL, PEORIA, ILL.

● tuesday morning *april 14* . . .

"Torsionally Resilient Drive Lines"
P. J. Mazziotti, *Dana Corp.*

Title to be announced
V. Holderman, *V. N. Holderman & Sons, Inc.*

technical chairman—H. V. Parsley
International Harvester Co.

● tuesday afternoon . . .

panel discussion on—Desired Trends in Earthmoving Equipment

"Off Highway Trucks"
L. J. Morgan, *M. A. Hanna Co.*

"Scraper and Wheel Tractor"
J. D. Armstrong, *J. D. Armstrong Co., Inc.*

"Track-Type Tractor"
J. M. Clark, *List and Clark Construction Co.*

"Motor Grader"
H. W. Hartmann, *McDougal-Hartmann Co.*

"Power Shovel"
C. H. German, *Midland Electric Coal Corp.*

technical chairman—J. E. Jass
Caterpillar Tractor Co.

● wednesday morning, *april 15* . . .

"Evolution of the Scraper"
E. E. Isgren, *LeTourneau-Westinghouse Co.*

"Faster and Further on Earthmoving Tires"
D. A. Clendenen, *Firestone Tire & Rubber Co.*

technical chairman—J. H. Hyler
LeTourneau-Westinghouse Co.

● wednesday afternoon . . .

"Radioisotopes and Research"
E. W. Landen, *Caterpillar Tractor Co.*

"Radioisotopes and Research"
W. P. Evans, *Caterpillar Tractor Co.*

"The Often Seen—Seldom Understood Bulldozer"
E. M. Wilson, *Caterpillar Tractor Co.*

technical chairman—H. H. Washbond
Allis-Chalmers Mfg. Co.

CRC Initiates Series of Statistical Surveys In Study of Octane Number Requirements for 1957 Cars

Table 1 — Maximum Octane-Number Requirements

All 1957 cars	No. Cars Tested	Octane Number for Indicated % Satsified			
Individual Makes	585	50% PR[a] 92.1	FBR[b] 94.3	90% PR[a] 96.6	FBR[b] 99.4
H234	25	96.5	98.5	99.0	101.5
I437	27	96.0	97.5	99.0	101.0
L436	28	95.5	99.0	99.0	102.5
J434	21	95.5	98.0	97.0	101.5
D435	16	94.5	98.0	97.0	101.5
M436	23	94.5	97.0	97.5	101.5
S436	24	94.5	97.0	97.5	100.5
D439	32[c]	94.5	96.5	97.0	100.0
N428	24	94.0	97.0	98.0	101.0
O431	21	93.5	95.5	96.0	98.5
L236	23	92.5	95.5	95.0	99.0
G436	28	92.0	94.0	95.0	98.0
O299	32	90.5	93.0	94.5	96.0
P230	33[d]	90.0	91.0	93.5	95.5
N228	27	89.5	92.5	93.5	96.5
K232	23	89.0	91.5	93.0	97.5
R225	21	87.5	90.0	91.0	94.0

[a] PR = Primary Reference Fuels
[b] FBR = Full-Boiling Range Reference Fuels
[c] 24 cars tested on full-boiling range reference fuels
[d] 21 cars tested on full-boiling range reference fuels

Table 2 — Average Octane Number Ratings & Fuel Identification Numbers

Blend No.	Composition, Volume Per Cent			Average Octane No.	
	RMFD-77-57	RMFD-78-57	RMFD-79-57	Motor	Research
1-C-57	–	2	98	78.7	84.0
2-C-57	–	11	89	79.8	86.0
3-C-57	–	22	78	81.0	88.0
4-C-57	–	33	67	82.2	90.0
5-C-57	–	46	54	83.4	92.0
6-C-57	–	59	41	84.6	94.0
7-C-57	–	66	34	85.2	95.0
8-C-57	–	74	26	85.8	96.0
9-C-57	–	82	18	86.3	97.0
10-C-57	–	91	9	86.8	98.0
11-C-57	3	97	–	87.5	99.0
12-C-57	25	75	–	88.9	100.0
13-C-57	43	57	–	89.9	101.0
14-C-57	57	43	–	90.8	102.0
15-C-57	73	27	–	91.9	103.0
16-C-57	88	12	–	93.1	104.0
17-C-57	100	–	–	94.1	105.0

THE first step in a series of yearly statistical passenger car octane number requirement surveys is reflected in CRC Report 331, "Octane Number Requirement Survey — 1957."

Based on data submitted by 29 laboratories, the 1957 survey involved a total of 587 cars which were selected in proportion to their population as determined by 1957 registration figures. Also included were 17 special-interest models.

Survey results are summarized below.

- The shape of the octane requirement versus speed curves varied considerably among individual cars of a given make. In general, the higher requirement cars had a tendency to knock at higher speeds than did the lower requirement cars. Cars having maximum requirement at 2950 rpm and above increased from 6% in 1956 to 13% in 1957.
- The percentage of cars having maximum knock at part throttle on full-boiling range reference fuels ranged from 0 for five car makes to 16 for make H234. It was about 6% for the total 1957 car population.
- Knock on tank fuel was reported by the owners of 21% of the cars but was found by the observers from 35% of the cars.
- Comparison of knock obtained with full-boiling range reference fuels and with tank fuels indicates that the full-boiling range fuels are representative of commercial gasolines in general at equal Research octane number.
- As in the past three years, surface ignition was reported as the limiting factor with full-boiling range reference fuels for slightly less than 10% of the cars tested.

The Research method was used to find the maximum octant number requirements shown in Table 1. These figures were attained through use of primary and full-boiling range reference fuel blends.

The primary fuel consisted of isooctane and normal heptane meeting ASTM specifications. It was blended in two octane number increments from 84 to 94. One octane number increment blends from 95 to 100 are also given.

Primary reference fuel blends of 101, 102, 103, 104, and 105 were prepared by addition of tetraethyllead to isooctane.

Full-boiling range reference fuel blends were prepared by cross blending three gasolines in two octane number increments from 84 to 94 Research

octane number and in one octane number increments from 95 to 105.

Average octane number ratings of the full-boiling range reference fuel blends as determined by ten participating laboratories and fuel identification numbers are shown in Table 2.

The sensitivities of the fuels above 99 Research octane number were lower in 1957 than in 1956. Below 99 Research octane number sensitivities were similar for both years.

CRC 331 contains 128 pages including graphs and appendixes.

To Order CRC 331 . . . on which this article is based, see p. 6.

Moisture Is Bane Of Air Conditioning

Based on paper by

VANCE REYNOLDS

A-P Controls Division, Controls Co. of America

(Presented before SAE Texas Section)

MOISTURE creates a major problem in automobile air conditioning systems. It gets into the system in a variety of ways. Some of them are:

- Faulty drying of equipment in factory or during assembly in the field.
- Wet oil or refrigerant, or both
- Low side leaks, such as a compressor seal leak.

Moisture separates from the refrigerant and causes icing whenever there is enough of it and the temperature of the refrigerant is sufficiently low. Ice may form in the orifice of the expansion valve to block it or to cause it to stick. Moisture will react with the refrigerant, oil, and temperatures met, to form hydrofluoric acid. The acid reacts with iron, copper, and aluminum to form sludges which will corrode the iron and steel parts of the system. It also causes the flapper valves or reeds to fatigue quickly.

Elimination of moisture will reduce maintenance and greatly extend the life of the system. Here's how to do it:

1. Keep all components capped until used.
2. Pressurize the system and check for leaks before pulling a vacuum on it.
3. Then pull a deep vacuum to remove all air and moisture. The vacuum must approximate 29.5 in. to vaporize any moisture condensed in the various components.
4. Change the drier-receiver or drier when the system is open for service or whenever a shaft seal leaks.

To Order Paper No. S128 . . . on which this article is based, see p. 6.

How to Improve Field Tests of Motor Oil

Based on paper by **D. C. BARDY and J. C. WALLACE,** Lubrizol Corp.

DURING the many millions of miles of field testing experience acquired by Lubrizol in the development of motor oils several things have been learned, some of which have been used to improve the validity and repeatability of earlier tests:

1. In continuous stop-and-go type service, engine oil temperatures are affected by manifold vacuum governors, particularly in the winter.
2. Oil consumption can affect test results, but may be partially controlled by:
   (a) Laboratory dynamometer engine break-in.
   (b) Physically limiting oil consumption to 500–1500 mpg.
3. Oil change interval can affect test results:
   (a) 3000 miles appears to be the optimum oil change interval.

When some of these principles are applied, field testing, as it pertains to the evaluation of motor oils, can be improved. Table 1 compares old and new test conditions. It shows differences between three cabs operating under a given set of conditions in two different tests. One test was conducted in 1956 and the other in 1958. Table 2 shows the degree of improvement that can be expected.

As can be seen, in the 1956 test overall sludge ratings varied almost three times as much as did those in 1958. Overall varnish ratings in the 1956 test varied twice as much as in the 1958 test. This is typical of a majority of the results obtained using some of the refined techniques that were developed. However, there are still many unknown facets to this type of operation and much room for improvement. It is hoped that further progress and a better understanding of some of the factors affecting the results of field tests can be obtained in the future.

To Order Paper No. 106C . . . on which this article is based, see p. 6.

Table 1 — Some 1956 and 1958 Test Conditions Compared

	1956 Test	1958 Test
Laboratory Engine Break-in	No	Yes
Oil Change Interval, miles	5000	3000
Oil Consumption Controlled between 500 Mpq and 1500 Mpq	No	Yes
Governors	No	Yes
Length of Test, miles	47,000	60,000

Table 2 — Spread in 1956 versus 1958 Test Results

(Oil: SAE 10W-30 solvent-extracted Midcontinent; treatment level: Supplement 1)

	Difference Between High and Low Taxicabs, %	
	1956 Test	1958 Test
Oil consumption, mpq	624	119
Sludge (100 — Clean):		
Rocker Arm Cover	46.0	24.0
Valve Deck	30.0	15.0
Side Plate	37.0	18.0
Push-Rod Chamber	25.0	15.0
Timing Gear Cover	11.0	5.0
Oil Pan	53.0	4.0
Oil Screen	10.0	0.0
Overall Sludge	27.6	11.4
Varnish (100 — Clean):		
Piston	16.0	4.0
Cylinder Bore	10.0	2.0
Rocker Arm Cover	20.0	20.0
Timing Gear Cover	15.0	10.0
Side Plate	0.0	0.0
Oil Pan	20.0	0.0
Overall Varnish	10.2	5.4
Overall Cleanliness	18.9	7.2

Photos of Gear Tooth Surfaces Issued by CRC

PHOTOGRAPHS of various types of gear tooth surface conditions have been released by the Coordinating Research Council as Manual No. 6. Also included is standard terminology used in the rating of hypoid differential gears.

The Manual is a slightly altered reprint of Attachments I and II of Appendix A of CRC Report No. 308, "Development of Test Technique for Determining Load-Carrying, Wear, and Extreme-Pressure Characteristics of Universal Gear Lubricants in Axles under Conditions of High-Speed Low-Torque Operation, Followed by Low-Speed High-Torque Operation (CRC Designation L–37–956)."

The document contains nine pages including illustrations. It is available from CRC, 30 Rockefeller Plaza, New York 20, N. Y. Price: $2 per copy.

Boiling Ranges Affect Antiknock Performance

THE boiling range of hydrocarbon types in gasolines tend to affect road antiknock performance, according to results of a recent cooperative study by Phillips Petroleum Co. and Ethyl Corp.

The research indicates that two gasolines of the same Research and Motor octane numbers and of the same overall hydrocarbon composition may differ significantly in road antiknock performance. A statistically based study of 20 fuels showed that such variation can be related to the placement of hydro-carbon types in the boiling range of the gasolines.

Olefins, for example, that boil at less than 210 F are shown to give better road performance at all engine speeds than do olefins boiling above 300 F. Similarly, aromatics boiling at less than 300 F are better during low-speed operation than are those boiling at higher temperatures.

At higher engine speeds, aromatic boiling range appears to have little effect on road performance of finished gasolines.

(The above digest is based on a paper by: F. D. Buerstetta and W. C. Healy, Jr., of Ethyl Corp., and L. A. McReynolds, Raymond Rohde, and H. C. Walters of Phillips Petroleum Co.)

To Order Paper No. 105C . . . on which this article is based, see p. 6.

Aircraft A-C Industry Needs Broader Horizons

Excerpts from paper by

I. N. PALLEY
Temco Aircraft Corp.

(Presented before the SAE Texas Section)

THE aircraft air conditioning industry can be as limited or as broad in its scope of effort as it desires to make itself. Today, it appears to me, it is in a very limited field of technology, concentrating primarily on development of mechanical equipment to provide temperature and airflow control suitable for human comfort. Humidity control is also provided in some cases, as is a cleanliness requirement for certain industrial environmental conditions. In the near future broad horizons exist for the development of techniques applicable to high performance aircraft and for vehicles whose objective is to probe the outer edges of our atmosphere and to initiate space travel. In these vehicles, precise control of temperature, humidity, pressure, airflow, and oxygen/carbon dioxide ratio are required. Chemical, electrical, and bacteriological means for regenerating carbon dioxide should be studied. These development problems are logical extensions of the present state-of-the-art within the capabilities of the aircraft air conditioning industry. An example I might point out is that a large corporation now has a contract for studying and applying thermal heating of aircraft structures as a source of energy for refrigeration of the crew and equipment compartments in manned hypersonic vehicles. For surface vehicles and fixed installations where people gather, methods and equipment must be developed to eliminate radioactive particulate matter from air. Also, separation of pollens, virus, ordinary dirt, and dust is a very fertile field for development by the industry.

Consider the following random samples collected from a very casual literature search:

1. The September 1958 issue of Proceedings of the Institute of Radio Engineers has an article entitled, "Analysis and Experimental results of a Diode Configuration of a Novel Thermoelectron Engine." This article describes a method for the conversion of heat directly into useful electrical work without using moving parts. Feasibility models have been tested at M.I.T. It is predicted that a value of thermal efficiency of greater than 10% is attainable.

2. Cryostat — a device for producing super low temperatures. Now with the advent of masers (low noise solid state amplifiers) and other semiconductor devices employing super low temperatures, the field of cryogenics (the science of low-temperature phenomena) will become increasingly important.

3. Solar heat as a source of energy for home air conditioning. The phasing of the cycle seems proper, that is, largest air conditioning load when energy available is highest, whereas for heating purposes the cycle is out of phase and creates serious heat storage problems.

4. Hilsch tube — this is a vortex device that will separate a high flow rate airstream into hot and cool channels. Is this a possible way of direct air conditioning for high-speed air breathing aircraft?

5. Electromagnetic gas pump — Would it be possible to ionize refrigerant gas by a radioactive source and apply the electromagnetic pump principle to achieve a compressor action with no moving parts?

These are but a few of the research paths which the industry might follow in developing new and expanded market horizons. I recommend the use of operations research techniques in estimating markets and probabilities and establishing priorities for research and development work. The byproducts of such operations research are at least as valuable as the actual results themselves. We feel that the objective thinking, the clarification of aims, and a pointed discussion of objectives, markets, probabilities, and capabilities stimulated by the operations analysis approach permit a much more thorough appraisal of the corporate situation than would otherwise be possible. The most difficult decision in management of an industrial enterprise is that of determining how much of today's profits will be retained and invested in research and development for tomorrow's goals. Four basic plans must be prosecuted simultaneously for a successful industry: first, the establishment of a rational research and development program; second, a long-range determination of the financial needs of the organization to fulfill these objectives; third, a facilities plan with which to implement the design, development, and production of the products and services; and fourth, an organizational development plan to fit the capabilities and relationships of the people within the organization to the research and development, facilities, and financial plans defined.

Planning and implementation in these areas will result in a healthy and progressive future for the air conditioning industry, as it has for the aircraft and missile industry.

To Order Paper No. S135 . . . on which this article is based, see p. 6.

Here Are Some Tips For a P-M Program

Based on talk by

PHILIP B. HOPKINS
Chrysler Corp.

(Presented before SAE Metropolitan Section; report prepared by Leslie Peat)

HERE is an 8-point program to help simplify preventive maintenance work:

1. Front Suspension System: Tire-wear pattern can be a tipoff to components needing attention. Other quick checks are made for loose or worn parts, loose or broken spring schackles, tight spring U-bolts on a truck, and loose wheel nuts.

2. Rear Axle: An inspection for lubricant leakage is made at the differential and wheels. Spring shackles and U-bolts are checked to make certain the wheel nuts are tight.

3. Brakes: Check the pedal free-play to make sure there is enough pedal. Look for loose or damaged

parts and for leaks in the system. Check the fluid level in the brake master cylinder at every 1,000-mile lubrication-period.

Condition of the brake linings can be checked when wheel bearings are being lubricated.

4. Cooling System: Look for coolant leakage and check the tightness and condition of the drive belts. Use a good rust inhibitor regularly in the cooling system. Use of the 180-deg thermostat brings the engine quickly up to operating temperature when the vehicle is driven continuously in top-go traffic, especially in winter.

5. Electrical System: First, the mechanic should check the battery terminals for corrosion and the charging circuit connections for tightness and good contact. If the terminals and connections are not tight and in good contact, the voltage check will not give a true reading. If the reading is not true, yet adjustments are made, it may do more harm than good.

To be safe, manufacturers' shop manual instructions should be followed. They explain exactly how to check voltage to get a true reading on the voltmeter.

Burned contact points usually mean high voltage and not the condenser.

6. Fuel Systems: *Carburitis* means that many carburetors are actually worn out by being taken apart too many times for cleaning, when it isn't necessary.

Because gasoline is practically dirt-free and efficient fuel filters stop dirt, the ignition system should be checked for the trouble usually blamed on carburetors. The actual trouble is more often *ignitionitis*, not *carburitis*. Most roadside failures are due to ignition system troubles. Early symptoms are hard starting, poor engine idling, and like conditions

7. Engine: The engine's most dreaded enemy is abrasive dirt particles. Therefore, the oil filter pipe cap air cleaner, the carburetor air cleaner, and the oil filter must do their jobs efficiently all the time.

Air cleaners and filter must be serviced as recommended. The paper insert in a dry-type air cleaner must be handled carefully, because the slightest puncture will let a great deal of dirt get into the engine.

Clogged oil cleaners will result in premature failure of engine parts.

After the air cleaners are serviced, the oil level is checked to make sure the supply is adequate.

Next step is to operate the engine, and check the oil pressure indicator to be sure the pressure is correct. While the engine is running, inspect its performance at idle and through other speeds, listening for abnormal noises indicating internal trouble.

Don't overlook the exhaust manifold heat valve. It must operate freely.

Be sure to adjust tappets correctly before putting the vehicle back into service.

8. Clutch: Check pedal free-play and look for loose or damaged parts.

In General

The paper filter should be cleaned every 5000 miles by tapping it lightly. Clean it by blowing out from the inside with compressed air. This does a better and safer job.

Years ago, an average oil gave satisfactory results. But today's engines, with their higher horsepower, impose a heavier load on the valve train, valves now open and close more rapidly, and a greater spring-load is now on the tappets.

Therefore, service MS oils with their special antiscuff additives, and which also retard sludge formation when engines operate at low speeds in stop-and-go traffic, are recommended.

Current use of resistor-type spark-plug cables with nonresistor-type spark plugs require new service procedures in removing the new cables. With the graphite cores, these cables must be grasped by the wire terminal and pulled straight off.

How to Combat Low-Temperature Wear

Based on paper by

T. H. RANDALL, R. E. ANDRUS, R. S. FEIN, and H. D. KLUGE

The Texas Co.

LOW-temperature wear performance is consistent with rings and cylinders being protected by an oil film which reduces the quantity of fuel combustion-product acids reaching the oil-metal interface. The acids and water apparently dissolve in the oil film rather than displace the film and then diffuse toward the oil-metal interface. Any increase in the concentration of acids in the combustion products increases proportionately the concentration gradient across the oil film and, hence, the rate at which the acids diffuse to and corrode the metal surface.

During the diffusion process, sufficient time is available for neutralization of part of the acids by alkaline additives in the oil. Apparently, the rate of this neutralization reaction is about the same for a variety of such alkaline additives. Acid that is not neutralized reaches the adsorbed layer of surfactive polar molecules that may be present from the base oil or from oil additives. This layer serves as a surface protecting barrier through which the acids must diffuse before they can react with the metal to form corrosion products. The effectiveness of the barrier depends on the packing of the molecules on the surface and the specific acids that are diffusing through the barrier. For this reason, oil additives that adsorb on surfaces and thereby effectively prevent mechanical wear due to intermetallic contact, do not necessarily form a sufficiently close-packed film to prevent some corrosive acids from reaching the metal surfaces.

Effective surface protection as well as alkalinity should be built into an oil since both neutralization and surface protection effects function simultaneously. Moreover, as a result of neutralization, the alkalinity becomes depleted through use and only the surface protection remains. Therefore, wear protection with extended oil use requires that the oil have effective surface protecting qualities. For modern high-octane leaded gasolines, which have very low sulfur content, these surface protection agents should be effective against chlorine as well as bromine acids from the ethylene dichloride and dibromide used as tel scavenger.

Since excessive oil consumption resulting from ring and cylinder wear is the most common reason for overhauling engines using detergent oils, it is important to reduce this wear to as low a level as possible. This can be done with alkaline-surface protecting oils with sufficiently frequent oil changes to take advantage of alkalinity.

To Order Paper No. 107A . . . on which this article is based, see p. 6.

Prediction Accuracy of ASTM Gum Test Doubted

SOUTHWEST Research Institute tests indicate that the existing ASTM gum test per se is not completely satisfactory for predicting the induction system deposit formation characteristics of gasolines.

This conclusion is the fruit of CRC efforts to meet an Ordnance Corp request to study the effect of fuel gum content on intake system deposits and general engine performance. It appears in CRC Report No. 325, "Phases IV and V — Stationary Engine Tests Run at Southwest Research Institute."*

The object of Phases IV and V tests was to obtain performance data on:

- A low gum fuel expected to promote induction system deposit formation characteristics of fuels.
- A fuel that contained a high gum

* Results of Phases I, II, and III appear in CRC Report No. 313, "Phases I, II, and III — Stationary Engine Test Run by Southwest Research Institute — Gasoline Storage Stability Auxiliary Engine Program."

content (using the ASTM test) and showed a low gum level after the residue was naptha washed.

In addition, the following conclusions are given as a result of the five fuels tested:

Greater induction deposits were obtained when an inhibitor sweetened unusual fuel with an average ASTM gum content of 4.6 mg/100 ml was used instead of another fuel with an average ASTM gum content of 10.9 mg/100 ml.

A fuel with an average ASTM gum content of 9.8 mg/100 ml, reduced to 4.4 mg/100 ml by naphtha wash of residue, displayed deposit formation characteristics similar to one having an average gum content of 6.5 mg/100 ml.

There is some evidence that the naphtha soluble portion of the residue of the ASTM existing gum test forms deposits quite different from the naphtha insoluble portion. For example, the fuel which contained a large portion of naphtha soluble gum gave smaller deposits in the unrestricted flow areas of the induction system but there was some indication of large quantities of hard deposits on the bearing surfaces of the intake valve guides and stems.

Assuming that the valve stem and guide bearing surfaces are points of heat concentration, a possible reason for the apparent differing characteristics could be that the naphtha soluble deposits are formed at elevated temperatures although insufficient data are available to explain the greater valve deposit tolerance indicated.

To Order CRC 325 . . .
on which this article is based, see p. 6.

Brake Linings for Reduced Wheel Sizes

Based on paper by

NEWELL H. McCUEN
Chevrolet Motor Division, General Motors Corp.

COMPARISON of capabilities and weaknesses of organic and metal linings shows both to have advantages and disadvantages. Neither is completely satisfactory.

Organics are more than equal to the demands of average daily driving. Metallics are equal to demands of "heat-problem" braking of police cars, sports cars, and other vehicles subjected to high-speed, prolonged decelerations.

Out of the healthy competition between organic and metallic friction materials will come the highly effective brake lining of the future, the brake engineer believes.

To Order Paper No. 14T . . .
on which this article is based, see p. 6.

Die-Cast Aluminum Saves Dollars and Weight

Based on paper by

W. C. CONOVER and R. C. NELSON
Outboard Marine Corp.

(Presented before SAE Detroit Section)

THE outboard motor industry is making powerplants that, on a small scale, rival the automobile engine. These powerplants are producing more power per pound, and more power per cubic inch than most piston engines. Die-cast aluminum parts are primarily responsible for this impressive achievement.

Advantages claimed for aluminum die-cast parts as compared with sand-cast iron parts include:

Production control — Scrap due to shifted cores, porosity, leaks, and the like is reduced substantially with die casting. Scrap percentage in gray iron cylinders is very unpredictable and makes production scheduling a diffi-

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What Is Required of Aerial Vehicle? L. M. HEWIN. Paper No. 10R. Outline of concept and principal purposes of aerial jeep in context of Army operations; operational considerations which include reconnaissance performance; desired characteristics with respect to configuration, cockpit, and general technical characteristics; consideration of cost factors in light of characteristics which appear to dictate use of gas turbine power plants.

Chrysler Aerial Research Vehicle Project, J. V. GORTON. Paper No. 10U. Chryler Corp development program for jeep research aircraft; phase 1, consists of engineering studies of lift, propulsion, stability and control of ducted propeller; phase 2, consists of detailed design, construction and component testing of aircraft; phase 3, concerns flight test program including tethered, hovering and free flight; particular reference made to research tools used in phase 1: wind tunnel, full scale static test bed, and computer simulation.

Stability and Control of Flying Platforms, M. O. McKINNEY. No. 10S. Fundamental problems of aerial jeep as currently visualized, based on experimental and analytical research by NASA; possible configurations consist of body for engine, pilot, and cargo supported by two or more propellers which are fixed with respect to airframe so that plane of rotation is horizontal for hovering flight; it is concluded that it can be made to fly satisfactorily in both hovering and forward flight but artificial stabilization may be required.

FUELS & LUBRICANTS

Priming Aids for Cold Starting Diesel Engines, J. J. DeCAROLIS, W. E. MEYER, P. W. ESPENSCHADE. Paper No. 101A. Research by Pennsylvania State University and US Army Ordnance Corps to investigate methods of applying priming fluids falls into three categories: direct cylinder introduction (including intermittent port injection), spray and vapor introduction into air intake system; details of each method; Penn State vapor applicator; comparison between results of vapor and spray introduction. Tables and 57 refs.

Multipurpose Laboratory Engine Test, D. T. ROGERS, F. L. JONACH. No. 105D. How Moto-Robot Controller, designed by Esso Research Co., operates together with type of dynamometer which can both electrically drive engine and absorb its power; ER 4-75 Test Procedure designed to reproduce results obtained in 16,000-mi field test with passenger cars engaged in urban and suburban driving; results obtained are checked against data from road tests and compared.

Radioactive Tracers Cast New Light on Fuel Distribution, D. E. COOPER, R. L. COURTNEY, C. A. HALL. No. 6T. To study fuel distribution in two V-8 engines, Ethyl Corp used individual fuel components, "tagged" with radioactive hydrogen or carbon-14; tagged components are blended into fuel, and their distribution to engine

cult task, which is reflected in the end cost.

Easier machining — The amount of finish stock can be reduced from 3/32 and ⅛ in. in cast iron to 0.030 in. in aluminum. This coupled with the difference in materials gives a surface machining rate differential of approximately 4 to 1.

Less machining — Holes are cored, surfaces are cast flat and ready for use without machining in many cases.

Uniform product — Wall thicknesses in die casting are uniform, and can be thinner than cast iron where strength is not a factor. Close tolerances can be held easily. Boss sizes are uniform and accurately located.

Cleanliness — Substantial improvement in plant cleanliness is achieved with die casting.

More design latitude — Bearings and inserts can be die cast in place. This reduces the total machining required and gives more design latitude.

Less capital equipment — Since the amount of machining and machining time is reduced, the total amount of capital equipment required is also reduced. This also reduces the machining floor space required for the same amount of production output.

Improved corrosion resistance — Outboard motors are often operated in salt water, and this salt water is pumped directly through the water jacket. With cast iron, corrosion deposits and salt buildup are severe. Water passages often become blocked and cause the engine to overheat. Die cast aluminum has virtually eliminated these problems.

Intricate designs — Die casting permits greater design perimeters for casting intricate shapes.

Accurate setup — Accuracy of locating in machine fixtures is good without primary machining operations.

Heat transfer — Aluminum has better heat transfer characteristics than gray iron.

Floor space — Floor space for die casting is substantially less than for the same volume in cast iron.

Mass production — Die casting is better suited to mass production because of uniformity and production control.

Cleaning — Cleaning is easier on the raw die casting. There are no core wires, or sand to get out of water jackets.

To Order Paper No. S146 . . . on which this article is based, see p. 6.

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cylinders determined by measurements of exhaust gas radioactivity; quantity distributed to cylinders is measured by exhaust-gas analyzer of catalytic-cell type; results reported include effect of various fuel, operating, and engine design factors.

Warm-Up Test Instrumentation in Laboratory, K. A. FRASSA, C. R. SMALL. No. 6S. Intrumentation developed by Socony Mobil Oil Co., using magnetic tape to program test cycle and strip chart recorder to study effects of fuel volatility and record engine performance; method of evaluating warm-up characteristics of passenger cars on chassis dynamometer; reproducibility of tests in terms of miles to warm-up was 0.4 on chassis dynamometer as compared to 0.6 on road.

Weather or Stall Carburetor Icing Control, D. P. BARNARD V, E. H. SCOTT. No. 6R. Laboratory test technique, developed by Standard Oil Co., to evaluate and control any fuel characteristics contributing to carburetor icing; tables showing test cycle, anti-icing merit rating scale, and base fuel volatility; fuel factors affecting carburetor icing are weather variable effect, fuel volatility, and gasoline additive effect; conclusions respecting each of these.

High Temperature Solid Film Lubricants for Uses Above 1000° F, R. E. CRUMP. No. 4S. In searching for acceptable solid film lubricants from among glass cermet ceramic combinations investigated, following ingredients were selected: graphite (synthetic), lead oxide, and porcelain enamel binder; recommended procedure for application of ceramic bonded solid film lubricant; mechanism of friction and wear; dependence of coefficient of friction on both, shear strength and metal hardness; test equipment for evaluating solid film lubricants.

Fuels, Engine Conditions, and Diesel Smoke, J. B. DURANT, L. ELTINGE. No. 3R. Three types of smoke are considered: black, white and blue; to determine how fuel properties and engine conditions affect blue and black smoke, tests were undertaken at Standard Oil Co., using one 2-cycle and one 4-cycle automotive diesel engine and smoke ratings obtained at both equilibrium and accelerating conditions; smoke measurement method; effects of fuel properites and engine conditions; nature and formation of blue smoke.

Some Concepts of Action of Antiwear Additive, S. B. TWISS, E. H. LOESER, R. C. WIQUEST. Paper No. 107D. Additive such as zinc dialkyl (C_5) dithiophosphate shown to be effective in preventing scuffing of automotive valve train components, techniques developed to measure magnitude of observed effects, including bench scale cam and tappet tester; use of Proficorder, radiotracers, and densitometer traces, and electron and light microscopy.

Performance of Zinc Dithiophosphate as Lubricating Oil Additives, C. S. SCANLEY, R. LARSON. Paper No. 107C. Research carried out at American Cyanamid Co.'s laboratory, Stamford; zinc dithiophosphate has marked effect on solubility, thermal stability, antioxidant and antiwear performance; radioactive tracer studies; comparison between laboratory and engine results are in agreement.

Look at Effects of Lubricant Additives on Surfaces, P. A. BENNETT. No. 107B. Some effects of "extreme pressure" or "boundary" lubricant additives on surfaces; discussion concerned with investigation of action of zinc dithiophosphate additives, chosen for study because they are widely used in automotive crankcase lubricants and little is published concerning their mechanism; lubricants and additives used; results of bench test performance.

Lubricant Additive Action in Combating Low Temperature Wear in Automotive Engines, T. H. RANDALL, R. E. ANDRUS, R. S. FEIN, H. D. KLUGE. No. 107A. Studies with 1-cyl gasoline engine comprising CFR crankcase and special power section developed at Texaco Research Center; SO_2 formed by combustion of sulphur in fuel and halogen acids from excess TEL scavenger are principal causes of corrosive wear; dependence of wear on additive alkalinity and surface protection characteristics.

Mechanism of Intake Valve Underside Deposit Formation, D. T. ROGERS, F. L. JONACH. No. 106C. Results of studies by Esso Research and Engineering Co., on mechanism of intake valve underside deposit formation in recent model passenger car engines; effect of fuel and lubricant composition on deposit formation; influence of engine design and operating conditions; information obtained from high speed motion pictures of operating intake valves; test techniques used.

Low-Temperature Engine Deposits — Results of Aberdeen Fleet Test, C. F. SCHWARZ, H. T. CLINE. No. 106D. Results of program, conducted with

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Ordnance in cooperative Coordinating Research Council Fleet Test to evaluate effect of oil formulation on amount of low temperature sludge deposited in engines; fleet consisted of ten V-8 and three 6-cyl sedans and 15 six-cyl, ½ ton capacity trucks; lubricating oil and fuels used; overall statistics on operation; engine ratings for deposits and wear.

Taxicabs in Motor Oil Field Testing, D. C. BARDY, J. C. WALLACE. No. 106A. Reference made to taxicab field test reported by R. H. ALBRECHT, R. I. POTTER, K. HYATT (Engineering Index 1956 p. 572); recognizing advantages of taxicab operation Lubrizol Corp. sponsored 15 million taxicab mi tests in last 3 yr using same basic techniques; number of facts concerning operational conditions and procedures useful in improving repeatibility and significance of results obtained; tables.

Road Antiknock Performance and Boiling Range of Hydorcarbon Types, F. D. BUERSTETTA, W. C. HEALY, Jr, L. A. McREYNOLDS, R. ROHDE, H. C. WALTERS. No. 105C. Fuel test program at Phillips Petroleum Co. and Ethyl Corp.; four approaches used: factorial analysis of 12 blends allowing and not allowing for sensitivity and olefins, and regression analysis of 20 blends, allowing and not allowing for sensitivity; how some performance variations can be attributed to differences in placement of hydrocarbon types.

Customers' Antiknock Rating, L. ELTINGE, H. R. TALIAFERRO, T. O. WAGNER. No. 105B. Research octane ratings do not adequately define antiknock performance of gasolines in cars on road; with aid of simple statistics different equations can be combined to yield Customers' Antiknock Rating, (CAR); 4 steps of which derivation of CAR consists; use of CAR improves comparisons of gasolines, quality control, evaluations of processes, and projections of future antiknock quality.

Volatility Tolerance of Passenger Cars in Mountains, A. P. McCLOUD, J. N. BARKER. No. 104C. Details of vapor lock test, conducted in 1957 in Colorado to determine volatility tolerances of passenger cars at various elevations, made in attempt to fill void with data taken at six different elevations ranging from 1100 to 11,400 ft;

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method of analyzing vapor lock data taken at various altitudes is presented; limitations of other methods of analysis; tables and graphs.

Vapor Pressure Tolerance of Fuel Systems, L. E. HEBL. No. 104B. New technique for measuring volatility tolerance proposed by Shell Oil Co.; it involves selection of fahrenheit temperature as scale of measurement, and converting each variable to equivalent of temperature; factors which can contribute toward vapor lock are added together to give expression of overall vapor locking condition; data obtained from road test programs; tables.

Measuring Hot Fuel Handling Characteristics of Automobiles, C. J. BRADY, D. R. JOHNSON. No. 104A. Characteristics determined by test method applied at General Motors, are loss in power, momentary cut-out, complete engine stoppage, poor idling, stalling in city traffic or poor hot starts caused by fuel vapor; details of test objectives, basic rules, vehicle preparation, instrumentation, fuels, facts about climatic test conditions and correction factors, driving schedules and data evaluation.

Application of LP-Gas to Light Automotive Equipment, C. F. LOFTIN. Paper No. 98B. Reference to butane and propane or mixtures of two; certain properties and characteristics of LP-gas make it ideally suited as motor fuel; economics involved in its use include low maintenance and fuel cost, less carbon monoxide and noxious fumes, increased safety; refueling facilities.

Designing Automatic Transmission Fluid, A. J. BOZZELLI. Paper No. 13T. Consideration of design aspects from viewpoint of petroleum supplier; design targets and requirements involving physical properties and actual transmission performance; how these properties are measured, and how they are achieved; recommendations made and closed cooperation between transmission manufacturers, seal suppliers, and fluid suppliers proposed to develop significant test procedure for evaluating seal shrink, and truly standard seal compound.

Correlation of Bench Oxidation Tests with Transmission Test Performance of Automatic Transmission Fluids, E. G. FOEHR, S. R. CALISH. Paper No. 13S. Performance criteria of transmission test are formulated; Modified Type C Oxidation Test, devised by California Research Corp., is proposed as low cost screening test, useful in predicting transmission test results; effects of base stock type and additives illustrated; agreement of bench test data with results in automatic transmission oxidation tests is shown.

LP-Gas Octane Numbers and Their Relationship to Engine Performance, W. G. ARMOR, H. G. INGERSON, A. G. HILF, J. N. JOBARIS, H. E. ALQUIST. Paper No. 6U. Study by group of companies of relationship between LP-Gas characteristics and knock limited performance of several bus and truck engines; results show that knock limited spark advance characteristics of blends could be rationalized in terms of research and motor octane numbers calculated and determined for blends; new approach to design mechanical octane numbers for gaseous fuels is suggested.

Evaluating Automatic Transmission Fluids, W. H. KITE, Jr, E. F. KOENIG. Paper No. 13R. Reference is made to SAE — Paper No. 756, 1956, by N. A. HUNSTAD, R. E. OSBORNE, and T. W. SELBY, indexed in Engineering Index 1956, p. 495; paper further reviews requirements of automatic transmission fluid, Type A, with particular emphasis on means and methods for determining performance of such fluids; details of tests for fluid characteristics and other motored transmission oxidation tests; durability cycling tests; squawk tests; tables and diagrams.

GROUND VEHICLES

Glass as Structural Member in Automobile Bodies, G. B. WATKINS. Paper No. 11R. Types of glasses; evaluation of safety glass glazings in terms of durability, dependability and mechanical strength; strength formulas; tempered or heat strengthened glass and its properties; laminated glass and types used for glazing motor vehicles and aircrafts; comparative resistance of different types and thicknesses of glass when subjected to impact, bending, and pressure loading; possible future trends.

Retrospection 1936 — Prophecy 1980, J. E. CHARIPAR. Paper No. 12R. Review of progress in automotive body styling of past 22 yr and predictions of future trends; present preoccupation with size and mass will be outgrown and interest will concentrate upon better use of space and materials, practical applications of aerodynamics, increased use of glass and glass-like materials in upper body areas, etc; expected changes in suspension, chassis layout, and body types.

Vehicles and Drivers — 1980, J. B. BIDWELL. Paper No. 12S. Review of progress made in past 20–25 yr and

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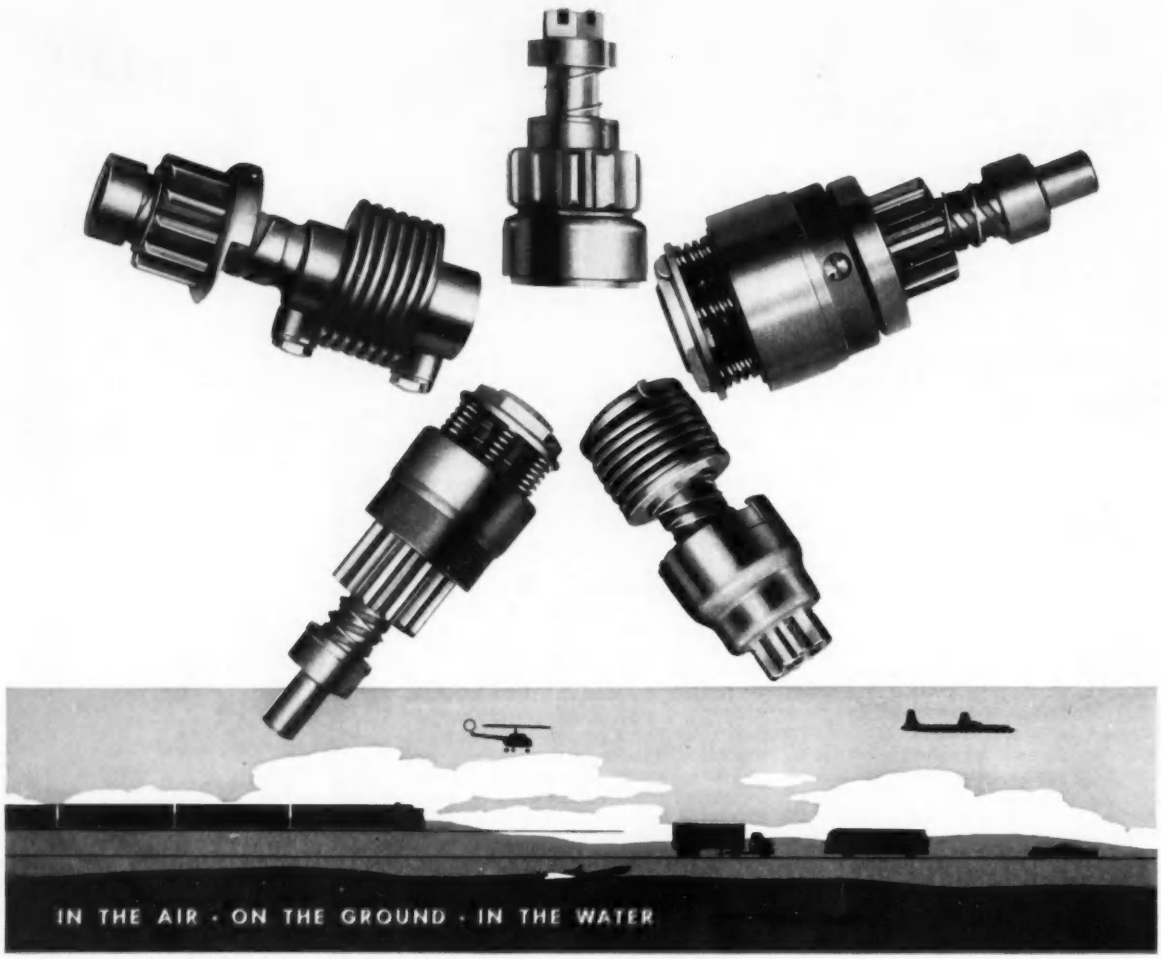

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Briefs of SAE PAPERS

Continued from page 107

analysis of possible future trends; major revolutionary changes will result from increased attention to driver-vehicle-highway relations and will include new driver control elements, and simplified instrumentation; dynamic properties of vehicles will be improved by new steering and suspension system; road information communication and completely automatic control for highway operation is foreseen.

Fashion on Four Wheels, R. H. MAGUIRE. Paper No. 12T. Ford Motor's approach to colors, fabrics and interior styling; examples of design for possible future interiors.

How Can Aluminum Best Be Used to Improve Today's Brakes? R. L. ATKIN, F. J. WEBER. Paper No. 14R. Tests made at Kelsey-Hayes Co. indicate improved heat dissipation is obtainable with use of aluminum but prove that benefit could not be fully realized with drum enveloped within wheel; types of drums evaluated and kinds of tests conducted; promising types of drum construction upon which development work centers are straight metallurgically bonded liner, shrink fit liner, sprayed steel liner and high Si-Al alloy drum.

Metallurgical Developments in Brake Drum, V. A. CROSBY. Paper No. 14S. Review of braking problem as applied to materials considering metallurgical, structural and chemical properties that account for mechanical properties required; use of higher carbon materials, including malleable iron, graphite steel, and low carbon high strength gray iron to obtain increased resistance to thermal shock and heat checking; properties and structures of cast iron drums; brake drum wear data; typical compositions that meet mechanical properties.

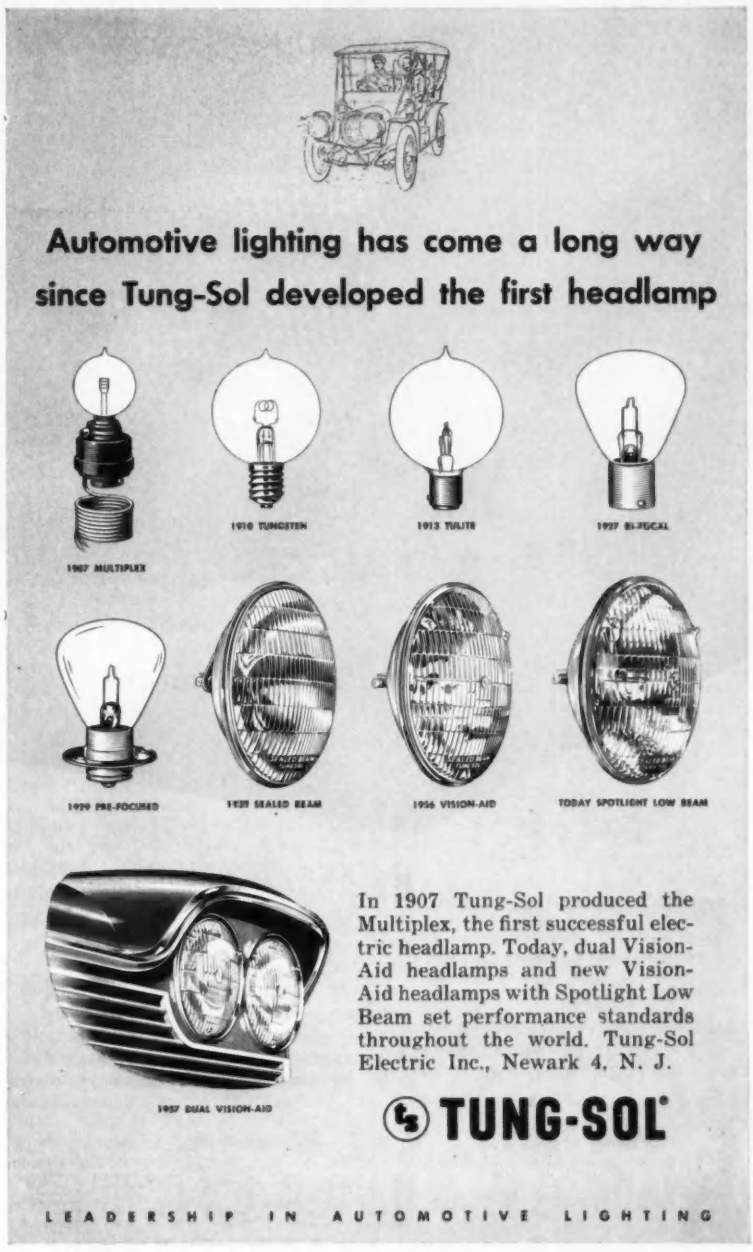
Brakes, F. T. COX, Jr. Paper No. 96B. Approach taken by Rockwell-Standard Corp., in obtaining increase in brake performance, in resistance to fade, and in wear life; summary of continued investigation undertaken to find newer and better means of dissipating kinetic energy stored in moving vehicle; general arrangement of brake illustrates trend followed to meet requirements of commercial vehicles; brake drum investigation.

Liquid-Cooled Brakes for Combined Retarding and Service Braking, J. D. DUDLEY. Paper No. 96C. Problem of designing better brakes for passenger and commercial vehicles and methods to improve brake's heat dissipating qualities; development of liquid cooled disk brake by Wagner Electric Co., designed for air-over-hydraulic actuation using power cluster with ratio of 11:1; results of test runs; fade test on tractor-trailer test vehicle and brake tests.

Some Aspects of Operation of Utility Engines, E. C. PAIGE, H. T. MUELLER. Paper No. 97A. Factors investigated include mechanism of deposit formation, effect of deposits on operation, design and maintenance problems, and deposit removal; tests to determine causes of deposits; heavy duty truck operation; passenger car service; constant speed and load service such as operation of refrigerators, fans, pumps, or generators.

Mechanical Approach to Utility Engine Combustion Chamber Carbon Deposit Problem, W. KLAUSLER. Paper

Continued on page 111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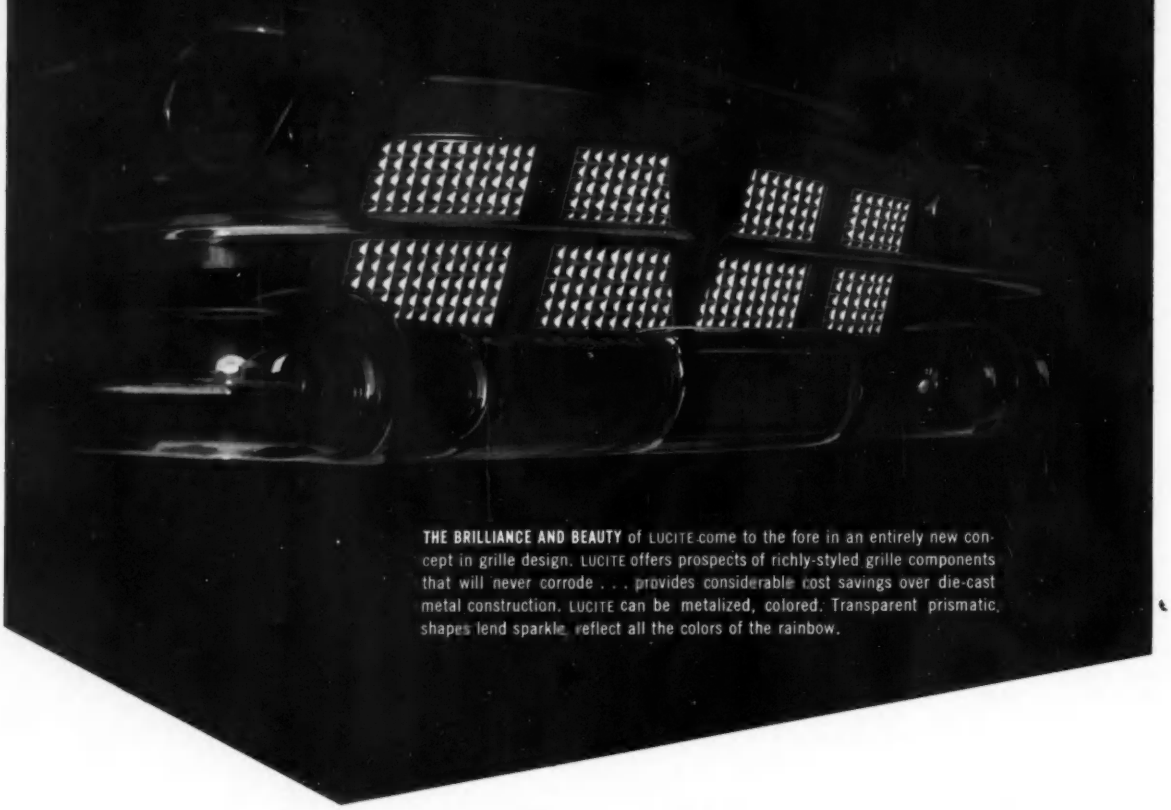

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Briefs of SAE PAPERS

Continued from page 109

No. 97B. Typical carbon deposit conditions; problem of obtaining desirable fuel for utility engines forming part of equipment in over-the-road truck operation; sources of carbon formation; recommendations for removal; maintenance program for operation of mechanical refrigeration units.

Diesel Engines for Use in Light Delivery Vehicle and Taxi Service, J. S. BRIGHT. Paper No. 98A. Range of engines specially developed by F. Perkins Ltd. include P4- 4-cyl engine developing 55 bhp at 2400 rpm in vehicles up to 10,000 GVW and 59 bhp at 3000 rpm in cars and taxi cabs; four 99 4-cyl in-line engine developing 43 bhp at 4000 rpm; particulars discussed show how closely engine meets requirements for which it has been designed; future applications.

Truck Cooling System Requirements, F. W. PERSON. Paper No. 99A. Functions of system; additional loads for cooling automatic transmissions, air compressors and additional oil coolers; tabulation of air-to-boil requirements that should provide satisfactory cooling for three classes of truck; military requirements; use of temperature control devices such as thermostats and bypass cooling systems; temperature controlled fans and radiator shutters; maintenance recommendations.

Truck Heat Exchangers, L. A. ZWICKER. Paper No. 99B. Factors which increase cooling requirements of engine cooling system; basis for measuring acceptable cooling control and definitions of two types of cooling index terminology, "air-to-boil" and "top tank over air"; military cooling requirements; three types of radiator core construction for light, medium or heavy duty truck applications; types of mounting used.

Truck Cooling System Airflow, E. R. KLINGE. Paper No. 99G. To measure actual installed air flows, use of system performance representation is proposed which permits relatively small amount of flow data to serve many purposes; data for each effect taken from different sources; their combination into single problem is only feasible for purposes of demonstration; requirements for use of fan at its best efficiency.

Design of Fiber Glass Cab, B. C. HARRIS. Paper No. 100A. Factors serving as basis for design of cab, made of fiber glass reinforced plastic, by White Motor Co.; engine compartment running longitudinally through center of cab is characteristic of cab-over-engine tilt cab design; use of aluminum extrusions for upper door portion.

Engineering Design of Fiber Glass Bodies, R. A. TERRY. Paper No. 100B. Decision to use fiber glass and reinforced plastics based on potential yearly volume requirements, assembly tooling available when considering change from metal to fiber glass, tooling budgets, length of time for tooling amortization, model run and configuration; ultimate design governed by type of tooling predetermined by economic factors; methods in use include hand lay-up vacuum bag method, and matched metal dies.

Production and Use of Molded Fiber Glass in Truck Cabs, J. R. HAMMOND. Paper No. 100C. Manufacturing processes and techniques used to produce 36 molded parts, by Molded Fiber Glass Body Co.; production is done in matched metal dies in hydraulic presses; steps taken to offset difference in flexural modulus; bonding methods.

Supercharging in Free Piston Cycle, H. G. SPIER. Paper No. 101B. Analytical studies backed by tests at Baldwin-Lima-Hamilton plant in Hamilton, Ohio; evaluation of three primary cases of supercharging: uncooled, intercooled, and scavenge air cooled cycles; series operation of supercharger and gasifier; problems of supercharger drive and matching characteristics of plant components; complete elimination of intake air pulses is main factor in adaptability to almost universal applications.

Thermal Loading and Wall Temperature as Functions of Performance of Turbocharged Compression Ignition Engines, E. T. VINCENT, N. A. HENEIN. Paper No. 102A. Method by which internal surface temperatures of cylinder walls can be predicted from knowledge of cycle pressure and temperatures when such is available; theory, experimental data, and analysis of results; reasonable agreement between calculated and measured mean surface temperature over wide range of operation, shown.

Evaluation of Aftercooling in Turbocharged Diesel Engine Performance, J. E. MITCHELL. Paper No. 103A. Approach taken by Caterpillar Tractor Co., to control thermal loadings of turbocharged diesel engines; air to engine water cooler is considered; successful application of aftercooling to vehicle engines in conjunction with higher pressure turbocharging to achieve increased output; use of simplified turbocharger control to expand utility of power producing package is shown.

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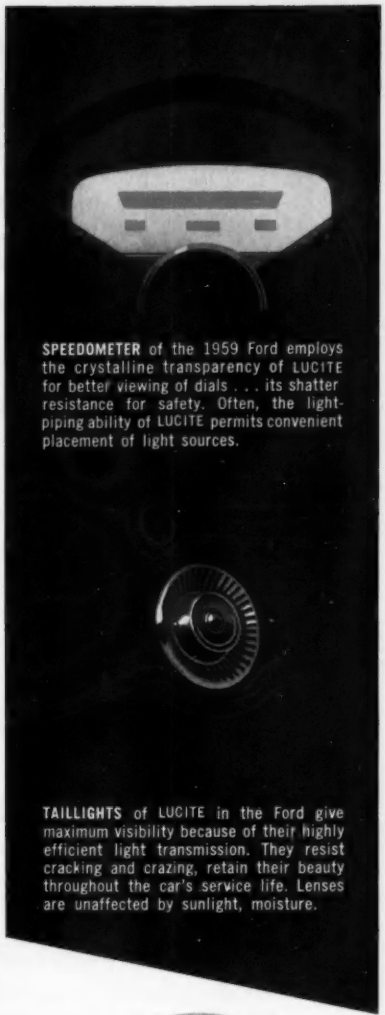

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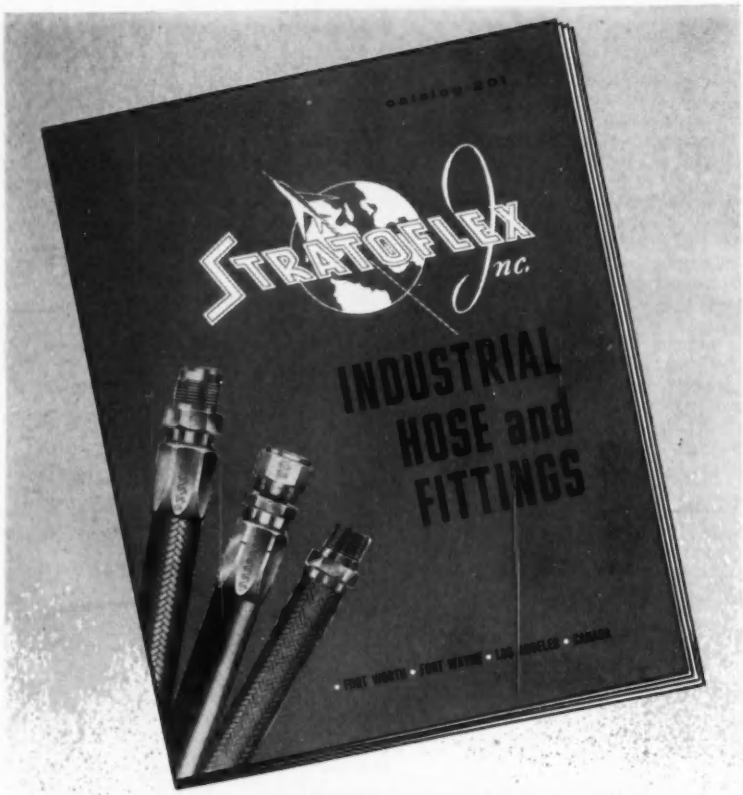

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Abnormal Combustion in High Compression Single-Cylinder Engines, R. W. YOUNG. Paper No. 105A. Study of cause of and solution for combustion phenomenon termed runaway preignition; effect was originally encountered and investigated in Cooperative Oil Test (COT) engine; fundamental cause has not been determined; it is promoted by engine design characteristics, such as high compression ratio and combustion chamber geometry and apparently occurs in absence of conventional surface ignition.

Fundamental Studies Related to Spark Plug Deposits, J. L. LAUER, P. J. FRIEL, R. D. MILLER. Paper No. 106B. Research at Sun Oil Co. concerning chemical and physical properties of spark plug deposits; development of instrument to measure basic physical property, viz., insulator leakage resistance as criterion of spark plug fouling, and engine tests simulating car road performance and aiding other studies; from results, means of spark plug fouling control by variation in fuel composition are suggested.

Solenoid Valve Capacity Control for Mobile Air Conditioning and Refrigeration Systems, K. E. WILSON. Paper No. S113. Problem of sudden loads and unloading of engine can be prevented by proper application of solenoid valve; range offered by General Controls Co. designed to aircraft shock resistant standards providing tight shutoff under all conditions including shock and vibration up to 25 G's; applications in various systems, such as bypass system, liquid line shutoff and in suction line.

Combination Receiver-Filter-Driers vs Separate Receiver-Filter-Driers, K. NEWCUM. Paper No. S131. Factors to consider in automobile air conditioning systems are: volume of receiver or dryer as it relates total system charge; its location on car; extent to which moisture absorbing and retention capacity of desiccant is affected by higher liquid temperatures and design as it relates to pressure drop or velocity effect upon desiccant and filter; experience made at Remco Co., manufacturing both types.

Testing of Automotive Air Conditioning Compressors, F. D. RANDALL. Paper No. S115. Design and durability tests to determine compressor compo-

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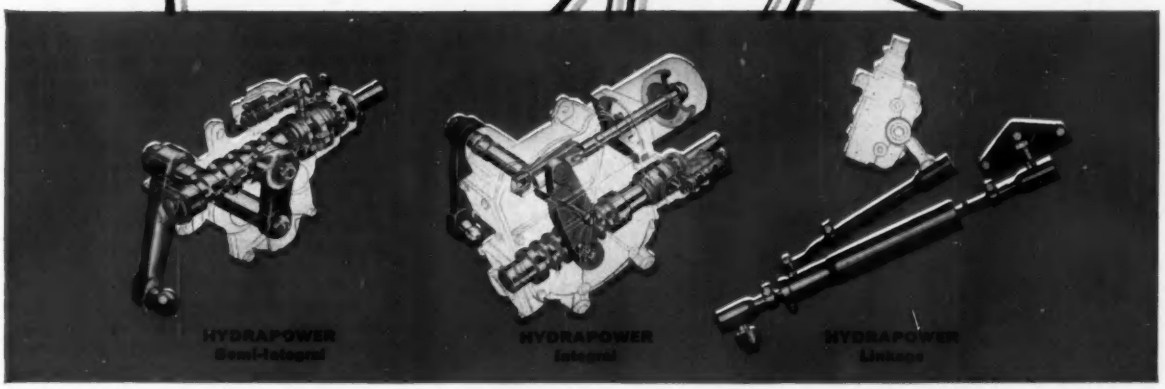

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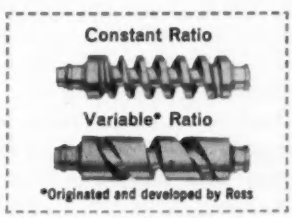

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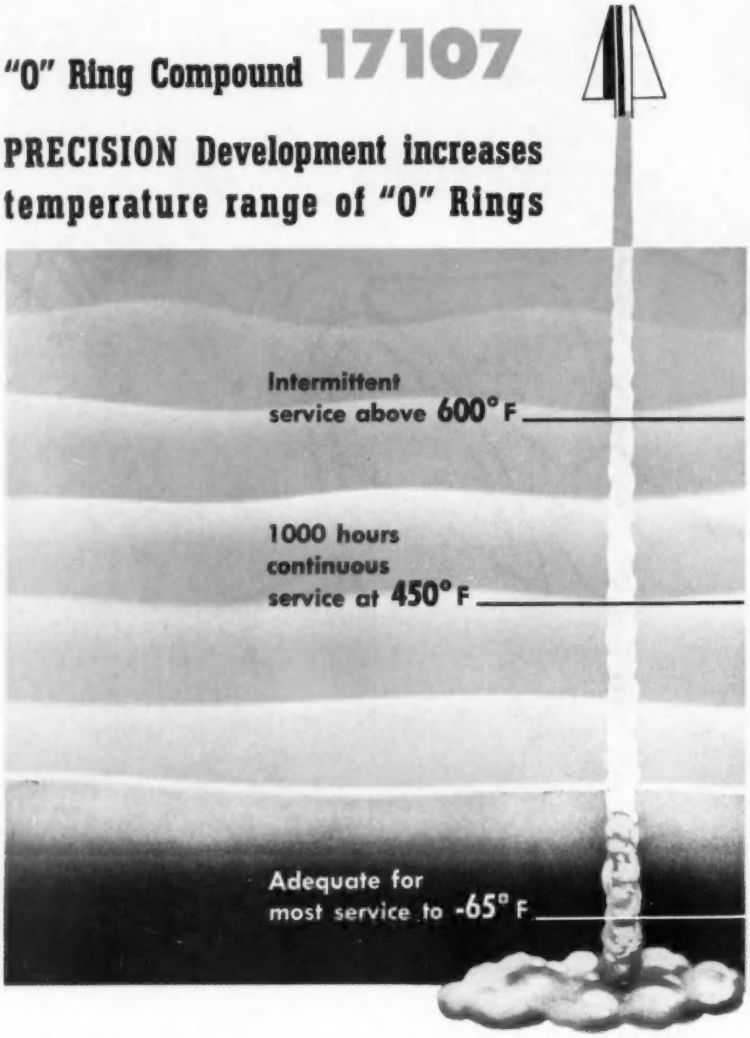

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nent durability, balance, capacity, horsepower requirement and efficiency, and performance tests; first group of tests proves ability of compressor to withstand extreme pressures, speeds, rapid cycling and high ambients; performance evaluation determines factors such as belt wrap, minimum pulley sizes and compressor bracket requirements.

Hazards of Moisture in Automobile Air Conditioning, V. REYNOLDS. Paper No. S128. Problems of moisture and how to prevent and remove it; methods that should be used in servicing to reduce moisture hazard.

Some Basic Considerations in Truck-Selection-Operation and Maintenance, L. T. FLYNN. Paper No. S121. Factors to consider in setting up vehicle specifications for particular job; how to set up maintenance program which entails planning, scheduling, training, analyzing, purchasing, driver training and reporting to management; how to make proper analysis of every phase of transportation activity shown in form of 22 questions.

History of Jaguar Cars Ltd. and Development of XK Engine and D-Type Racing Car, C. G. BENETT. Paper No. S117. Background of company; development of various types of sport cars and engines; 3.8 liter XK engine develops 300 bhp at 5500 rpm; various body shapes with particular reference to D-type; data relating to effect of wind pressure on body upon weight distribution, and acceleration; use of disk brake.

Automatic Transmission for Trucks, R. M. SCHAEFER. Paper No. S118. Use of hydraulic torque converter type transmissions; types available and appraisal of various well known transmissions for highway and off highway trucks; operating experience; advantages of converter driven power take-off.

Developing Leaders at Fisher Body, J. E. GOODMAN. Paper No. S122. Approach taken by Body & Assembly Divisions of General Motors Corp.; five areas outlined where improvements, new ideas and developments are needed relating to rusting metal parts, sealing, substitute for glass, application of garnish moldings, and new approach in construction of seats.

Good Is Not Good Enough, E. N. COLE. Paper No. S123. Advances

Continued on page 116

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Continued from page 114

made by automotive engineers in past 25 yr; areas where improvement is needed and problems to be dealt with: reduction of weight; incomplete combustion of fuels; development of reliable components and cars within short time allowed for each new model; possible use of increased aluminum in cars and trucks; experimental V8 aluminum engines, etc; possible future trends.

GM Diesel's Additional Engines New Vees and In-Lines, K. L. HULSING, C. E. ERVIN. Paper No. 1R. Progress achieved from 1937–1955; design and performance features for new Series V71 and 53 engines; development of Series 71 "E" engine to date has yielded cleaner exhaust with equal power, improved fuel economy, longer life, and superior altitude performance; minimum weight is achieved by general reduction of casting walls to 3/16 in. wherever consistent with requirements; other particulars.

Valve Gear Oil Consumption, V. C. VANDERBILT, Jr. Paper No. S127. Factors to consider in design of valve gear; design of valve ports, valve seats, and structure surrounding valve area, has marked effect on performance of engine; problem of oil loss from engine; reference to Teflon seal, encased in elastomer jacket; Teflon insert withstands temperatures above 500 F; results of test using these seals.

MATERIALS

Use of Radioactive Tracers in Rubber Research, S. D. GEHMAN. Paper No. 8R. Use of tagged sulphur in unvulcanized rubber mixture is basis for laboratory method for determining amount of sulphur which combines chemically with rubber during vulcanization; examples of tracer methods used in physical chemistry of rubber; tracer studies of vulcanization reactions; methods used in Soviet Union to measure solubility and diffusivity of sulphur in rubber.

PRODUCTION

Numerically Controlled Milling Machine, P. H. McGARRELL. Paper No. S126. System, developed at Thompson Products and applied to Cincinnati 16 × 30 Hydrotel, represents marriage of analog techniques of tracer servo control and digital computer techniques and is configured for guidance of four machine axes, table, cross slide, and spindle and rotary axis; information flow; programming; feedback units.

Recent Developments Make Engineering Specifications More Realistic, D. SHAININ. Paper No. S125. Sample of "statistical engineering" techniques presented that reconciles two different objectives in setting specification, amenability to production processes and ability to function as intended; fundamentally, methods add objectivity to procedure for evaluating specifications by providing basic factual information; checking important tolerances for size.

Presented here are brief digests of recently presented SAE papers. These papers are available in full in multilith form for one year after presentation. To order, circle the numbers in the "Reader Information Service" blank on page 6 corresponding to the numbers appearing after the titles of the digests of interest to you.

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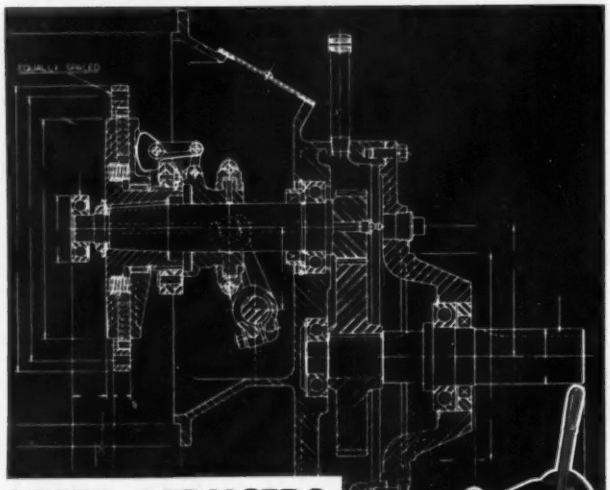

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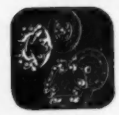
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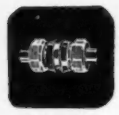
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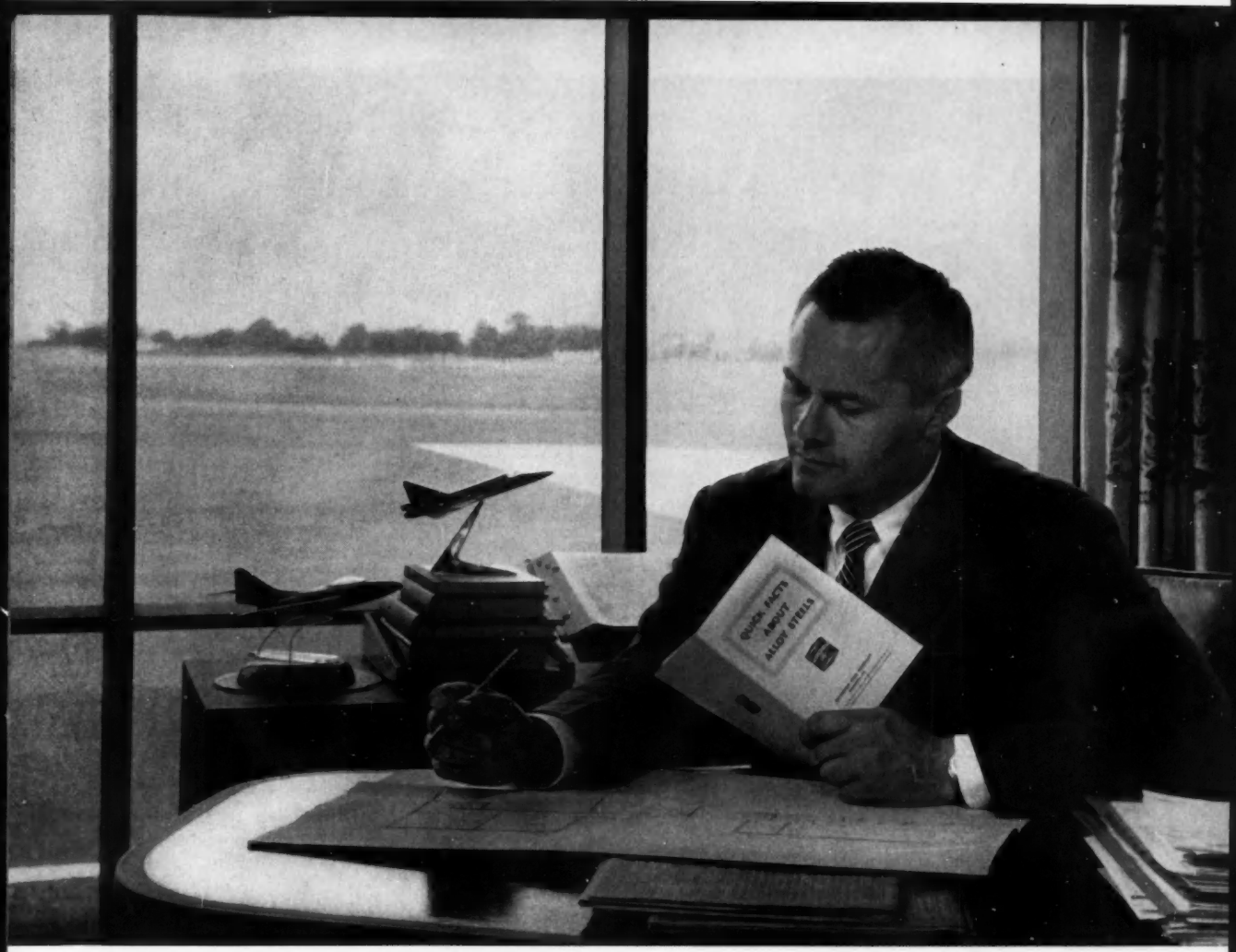

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This is just one application of the big capacity "HC" series. There are many more. On all types of heavy industrial and road building equipment it powers demanding hydraulic jobs with speed, stamina and reserve.

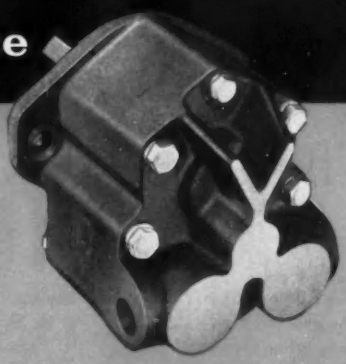
And, there are additional reasons engineers specify the "HC" series . . . they're compact, adapt easily to the product and job, dependable. That's why when you figure on Webster, it adds up to *the dynamic difference that pays!*

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

RACINE · WIS

our 50th year



"HC" SERIES POSITIVE DISPLACEMENT GEAR-TYPE PUMP

Shaft seal: lip type
Drive: direct, gear or belt
Capacity: 5 sizes, 5 - 17 gpm
Pressure: to 1500 psi
Operating speeds: to 2400 rpm
Porting: side (Std.) end (Opt.)
Valve: optional; internal relief, adjustable 800 - 1500 psi

BULLETIN HY1A gives complete engineering characteristics — performance and installation data.

Call the man from Webster

. . . he's one of a staff of engineers specially trained in hydraulic application. He can help you solve special problems when hydraulics become a part of your design.

photo . . . courtesy J. I. Case Company, Racine, Wis.

New Members Qualified

These applicants qualified for admission to the Society between January 10, 1959 and February 10, 1959. Grades of membership are: (M) Member; (A) associate; (J) Junior.

Alberta Group

Arthur Hollings (M), Rene J. Trudel (J).

Atlanta Section

Meldon Frank Hurlbert (A).

Baltimore Section

Capt. Robert E. Cook (M).

British Columbia Section

Ben Berto (A), Russell Gordon Fraser (J), Robert Hugh Morris (M).

Buffalo Section

Louis N. Friol (M), George T. Miller, Jr. (J).

Central Illinois Section

Paul Harold Brandes (J), Merwyn Dean Lackbee (J), R. Dale Philipsen (J), Glenn Eldon Stewart (J).

Chicago Section

Oscar Henry Banker, Jr. (J), Anthony J. Bender (A), Frank Budreck (A), Donald E. Kuska (M), David B. Puryear (M), Howard C. Shaw, Jr. (M), Ronald Wade (J).

Cleveland Section

Roy P. Allen (J), Tadeusz Budzich (M), Eugene Hervey (M), Edward Wm. Kochevar (A), Raymond W. Kupp (A), Thomas A. Michelhaugh (J), John P. O'Donnell (J), John R. Poyser, Jr. (M), Karl F. Reed (M), Ross E. Stewart (M).

Dayton Section

Donald J. Clark (M), James S. Glasgow (J).

Detroit Section

Floyd C. Biggs (M), Raymond B. Boardman (A), Mody Keefer Boatright (J), Gerald Alfred Confer (J), Robert E. Crink (J), Charles R. Denton (M), Paul William Emanuelsen (J), Vincent James Graziano (J), Howard A. Groombridge (M), David Lavern Hart (J), Edward Haug (J), Carl Arthur Hawthorne (J), J. Robert Howland (M), John Murray Lidkea (M), Roger E. Maugh (J), Carl C. Runyon (M), David C. Salatin (M), Edmond J. Schneider (A), James F. Shuller (J), Homer M. Swineford (A), A. K. Thomas, Jr. (A), John Curtis Walker (J), Thaddeus Frank Zoltek (M).

Indiana Section

Kenneth A. Apple (M), Henry Keith Arnold (M), Thomas Joseph Bertrand (J), Gerald Leroy Cameron (M), Curtis T. Cox (M), Dale William Driscol (J), Walter A. Gammel, Sr. (M), C. Edward Johnson (M), Allen Jean Moe (M), Oskar Wagner (M), Adolph J. Weigand (M), George W. Youndt (M).

Metropolitan Section

Kurt S. Ellner (M), Robert G. Greulich (J), Theodore M. Krewski (J), William R. Lozier (A), Albert Raynor Mead (M), Alexander J. Ozarowski (M), Isaac Stewart (M), Anthony Thompson (A), Dirk W. Van Nest (A).

Mid-Michigan Section

Arthur W. Bradley (M), A. J. Dunkle (M), Richard P. Riefel (J), Melvin A. Schultz (M), Kenneth L. Westercamp (J), Robert Derry Wight (J).

Milwaukee Section

J. F. Dindorf (A), John M. Durham (A), Louis C. Haltug (A), Robert T. Larsen (M), Joseph W. Marchello (J), Robert K. Ruland (A).

Montreal Section

Derek Angus (J), Lt. Richard Neil Patterson (J), Richard Graham Stewart (J), James W. Ussher (M).

New England Section

James Q. Adams (A), Kenneth A. Campbell (M), Chester J. Orciuch (M).

Northern California Section

Warren P. Boardman, Jr. (M), Paul Adam Fruehauf, Jr. (M), Frank S. Larrowe (M), Jack Ernest Shinn (A).

Northwest Section

John William Culpepper (J), Teijiro Namatame (M), William Herbert Sarjeant (M).

Ontario Section

William James Abrams (J), Philip T. Bachand (A), Lennard Maurice Brown (J), John Henry Goode (M), Lawrence Harvey Iron (J), W. H. Mason (A), Frank M. Russell (A), Carleton C. Strahm (A).

Oregon Section

Ronald E. Meisner (J).

Philadelphia Section

David Seeley Blew, III (J), William Kenneth Greisinger (M), R. Edward Lodico (J), Harry J. Warmkessel (M).

Salt Lake Group

Foss B. Sessions (A), James Albert Smith (J).

San Diego Section

William Walter Fox (M), John Whittington McGruer (M), William R. Updegraff (J).

South Texas Group

Heinz Gunter Buschfort (J).

Continued on page 121

NEAREST MAN ON WHEELS

He's the ELECTRIC man with the ideal Midwest location. Call him today for lightning-quick service.

Call on the kind of experience only a farming and industrial area sales engineer can offer you. Call on a man who comes equipped to quote production schedules and prices, while working with you on the job.

In short, call ELECTRIC. Get seasoned help, backed by the capacities and qualities of an automated operation and years of manufacturing experience.

Call or write today for the exact disc or spoke-type wheel (steel or rubber-tired), rim, hub, axle or component part you want—when and where you want it.

"What we sell is service"

ELECTRIC WHEEL CO.

Write to Department 118
1120 N. 28th St., Quincy, Illinois, BAldwin 2-5320

DIVISION OF THE FIRESTONE TIRE & RUBBER COMPANY

SOLVING PROBLEMS COMES EASY

WITH SAGINAW b/b SCREWS!

SOLVED EXCESSIVE POWER CONSUMPTION

SOLVED SPACE/WEIGHT PROBLEMS

SOLVED PRECISE POSITIONING

SOLVED TEMPERATURE EXTREMES

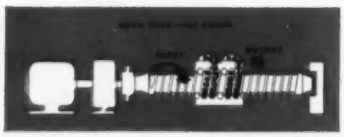
SOLVED LUBRICATION

SOLVED DEPENDABILITY

THE MINIATURE b/b SCREW
Used where *miniature* positioning/control precision and dependability is essential in telemetering and guidance systems, antenna coupler tuning, and similar diminutive actuating applications.

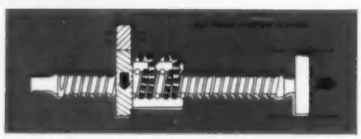
THE SAGINAW b/b SCREW
Used in afterburner controls, elevon positioners, as speed brake actuators, in clamping mechanisms for missile boosters, and many other applications.

ACTUATE AND POSITION WITH OVER 90% EFFICIENCY . . . 4/5 LESS TORQUE!



NUT TRAVELS: When rotary motion is applied to the screw, the b/b nut glides along the axis of the screw on rolling steel balls, converting rotary force and motion to linear force and motion with 4/5 less torque than acme screws.

SCREW TRAVELS: When rotary motion is applied to the b/b nut, the screw glides along its longitudinal axis on rolling steel balls, converting rotary force and motion to linear force and motion with unprecedented efficiency.



1 **SAVES POWER.** Operates with almost 100% efficiency. Saginaw b/b Screws permit much smaller motors with far less drain on electrical systems, also simplify circuitry.

2 **BROAD TEMPERATURE TOLERANCES.** Normal operating temperature for Saginaw b/b Screws is from −75°F. to +275°F. In selected materials they will function efficiently at temperatures as high as +900°F.

3 **SPACE/WEIGHT SAVINGS.** Saginaw b/b Screws are compact. They permit smaller, lighter motors and gear boxes and eliminate cumbersome auxiliary equipment.

4 **NO LUBRICATION NEEDED.** If lubrication fails, the Saginaw b/b Screw will still function with remarkable efficiency. Units have been built and qualified for operation without lubrication.

5 **POSITIONS PRECISELY.** Saginaw b/b Screws will position components far more precisely than hydraulics or pneumatics; tolerances on position are held within .0005 in./ft. of travel.

6 **DEPENDABLE PERFORMANCE.** Saginaw b/b Screws are far more reliable than hydraulics or pneumatics. Gothic-arch grooves, yoke deflectors and multiple circuits provide added assurance.

SEND TODAY FOR FREE 1959 ENGINEERING DATA BOOK . . .
or see our section in Sweet's Product Design File

Available in custom machine-ground and stock rolled-thread types. Units have been built from 1½ inches to 39½ feet long—⅜ to 10 inches in diameter.

Saginaw ball bearing Screws and Splines

SAGINAW STEERING GEAR DIVISION OF GENERAL MOTORS • SAGINAW, MICHIGAN
WORLD'S LARGEST PRODUCER OF BALL BEARING SCREWS AND SPLINES

New Members Qualified

Continued

Southern California Section

Harlan Clark Ballentine (A), Russell B. Boyer (M), Warren Coleman Bullis (J), John Raymond Burrows (J), Walter T. Camp (A), Hiram J. Coe, Jr. (M), Robert Leroy Embry (J), Gerald Duane Foster (J), Elliott A. Green (M), Max V. Greeven (J), David W. Grimm (M), Joseph W. Gunn (M), Raymond H. Nickerson (M), James Benham Pray (M), Gerald David Ritland (J), William A. Rohrer (J), John A. Schroth (J), Wilfred H. Shaw (M), Bernard van Aalst, Jr. (J), Nevel Frank Vanover, Jr. (J).

Southern New England Section

Donald V. Gervais (M).

Syracuse Section

Horace Hugh Christensen (M), Joseph W. Poliseo (M).

Texas Section

Jimmy J. Dorland (A), Merlin Lee Green (J), John P. Thomas (M).

Texas Gulf Coast Section

David Lawrence Crowell (M).

Twin City Section

Ahmed A. Dadi (J), Donald K. Mayer (J).

Washington Section

John Augustine O'Keefe, Jr. (J).

Outside Section Territory

Elton M. Avery (M), Howard L. Dahlstrom (M), Henry John Kinsey (A), Bruce N. Lewis (J), Maynard Walter Slack (J), Frank J. Strnad (M), Merrill Tate (A), Arthur Webb (M), Robert C. White (A), Homer D. Witzel (M).

Foreign

C. W. E. Cary (M), England; J. Stanley Clarke (M), England; Howard D. Crotts (M), Sweden; Francis Patrich John Dusting (J), England; Michael Stanley Reed (A), Argentina; David Clifford Riley (J), England.

Applications Received

The applications for membership received between January 10, 1959 and February 10, 1959 are listed below:

Alberta Group

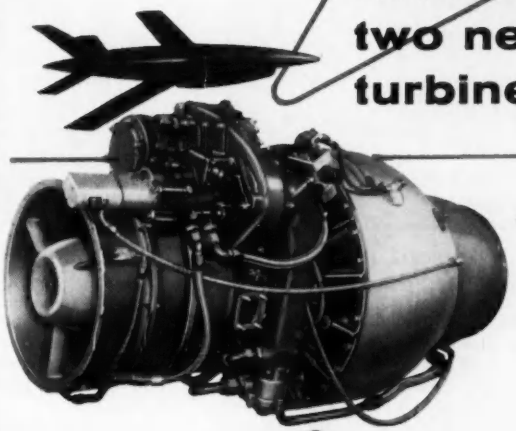
Lloyd Shuler

Continued on page 123

CAE...

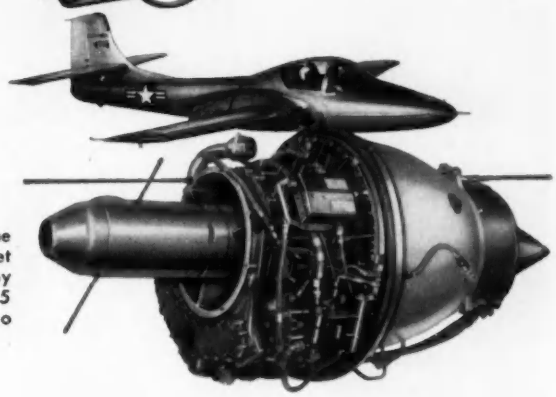
PRODUCERS OF SPECIALIZED POWER

Announces two new turbines



J69-T-29A

1,700 lb.-thrust model for drone applications. The new engine has 60% more thrust with only a 6% increase in weight. It is presently powering the Ryan Q-2C target drone which recently underwent successful flight tests.



J69-T-25

Latest power plant for the Air Force T-37A twin-jet trainer manufactured by Cessna, the J69-T-25 has increased thrust to 1,025 lbs.

CAE has more than 10 years of turbine engine experience in the medium and low power range. The Air Force MA-1A trailer-mounted turbine air generator manufactured by CAE is on duty at air bases the world over, demonstrating outstanding performance and reliability.

CONTINENTAL AVIATION & ENGINEERING CORPORATION

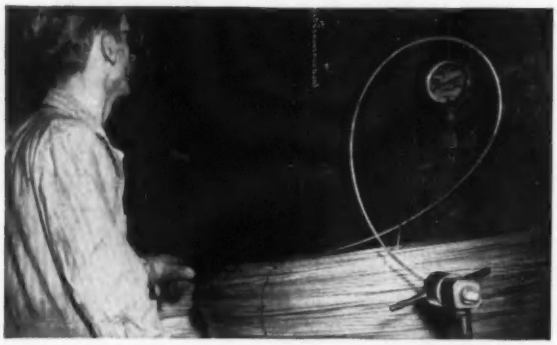
12700 KERCHEVAL, DETROIT 15, MICHIGAN

SUBSIDIARY OF CONTINENTAL MOTORS CORPORATION

STEEL TUBING TIPS:

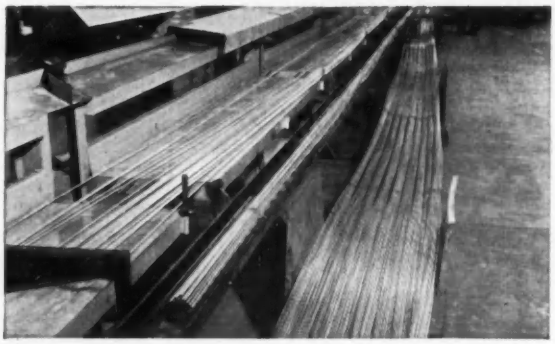
HOW TO DETERMINE YOUR BEST TUBING VALUE!

Compare the tubing you now buy with these extra-value features available to you at no extra cost!



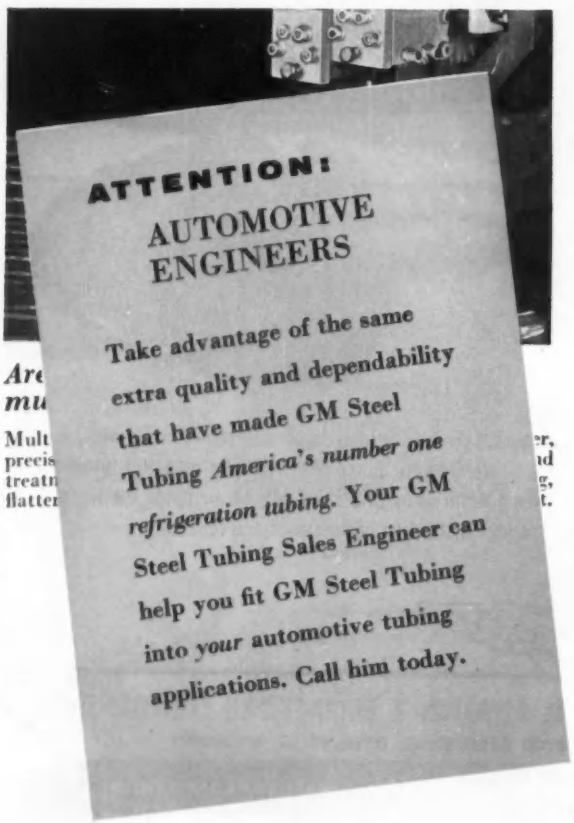
Is every inch of your present tubing pressure-tested and cleaned?

Every inch of GM Steel Tubing is pressure-tested and cleaned. Solvent is introduced under pressure to all bulk coils, checking structural strength and assuring an I.D. free of internal residue and cleaned to many times specifications.



Is your tubing rotary-straightened before serpentines are formed?

All straight lengths of GM Steel Tubing are rotary-straightened to maximum lengths of 80 feet. This process assures serpentines with better "flatness" characteristics for contact at all points on weld-wire condensers.


ATTENTION:
AUTOMOTIVE ENGINEERS
Take advantage of the same extra quality and dependability that have made GM Steel Tubing *America's number one refrigeration tubing.* Your GM Steel Tubing Sales Engineer can help you fit GM Steel Tubing into *your* automotive tubing applications. Call him today.

Are mu

Mult... precis... treatm... flatter...

Is every serpentine double-checked—pressure-tested and cleaned?

After each serpentine is formed, it is individually pressure-tested and cleaned to assure further quality and dependability. These are just a few of the many extra-quality controls available with GM Steel Tubing that cost you no more.

GM STEEL TUBING

BY ROCHESTER PRODUCTS

DIVISION OF GENERAL MOTORS
ROCHESTER, NEW YORK

Applications Received

Continued

Baltimore Section

Roger F. Hansen, Jack D. Lane, Jr., Robert W. Shipley

Buffalo Section

Albert Granville Fonda

Central Illinois Section

Michael R. Gallagher, George E. Hammel, Jr., Robert D. McFeeters, Dale Edward Pflederer, Albert Edward Rust, William D. Saathoff

Chicago Section

Henry O. Barth, H. Thomas Douglas III, Herbert R. Dover, Arthur William Garlieb, John C. Hedberg, Walter J. Kudlaty, John T. Parrett, Edward Yatsko, Jr.

Cincinnati Section

Miles A. Townsend

Cleveland Section

Richard H. Focke, Ralph Emerson McKelvey, Dr. R. S. Ross, S. T. Salvage, John H. Shroyer, Jr., Robert William Young

Colorado Group

Robert E. Stetson

Dayton Section

Roger C. Binnig, Robert W. Mathews

Detroit Section

Julian N. Andrews, Kenneth L. Buck, Earl L. Butler, Henry L. Byrne, Traian Cabba, Robert F. Childs, Glenn E. Couse, Emile S. Dahel, Frederick E. Detke, Ralph DiCicco, William J. Durako, Robert Everett, George Charles Farhood, Gordon William Goodwin, Merrill L. Haviland, Othello M. Hillman, Carl F. Hoehner, George P. Holman, Ian R. Kiltie, Harold William Krauss, Adolph P. Loeber, George Mardiros, Jr., Philip O. Mastin, Jr., Donald Irving Mullett, J. H. Nourse, Francis G. Olsen, Jack A. Pascoline, Hans Egon Petersen, Arthur C. Pope, Richard S. Radomski, William Edward Rowe, William M. Ruhala, Bruce M. Scott, Robert E. Shelhart, Dale W. Toms, Allan Lee Turner, Richard K. Wheeler

Hawaii Section

Eric Holloway

Indiana Section

James Allen Beaumont, Walter G. Chew, H. J. Claypool, Jack Covitt, Charles L. Dusenberry, Richard Howard Duzan, Walter J. Fisher, Eugene Richard Hafner, William P. Henson, Anthony Kleis, Hugo V. Kojola, William E. Martus, Jr., Charles A. Pickett, Robert J. Pielsticker, Gerald M. Ridgeway, Willard C. Shaw, Roderick Harris Spann, Byron L. Stewart, Wayne H. VandeSteeg, John W. Waltemath

Kansas City Section

Richard E. Brecko, Henry Thomas Fryc, Jr., Evan L. Hopkins, Cyril Pope, John Lawrence Taylor

Metropolitan Section

Louis Achitoff, Clare E. Bacon, Hugh Richard Brossy, Lorin W. Curtis, Dickerson F. Cutler, Frank G. Daleo, Chester G. Davis, Frank J. Ehringer, Wesley H. Schmittner, Shepherd Sikes, Kenneth J. Skoglind, Anthony W. Wilk

Mid-Michigan Section

David F. Biggs, John Gold, Thomas G. Gorman, George W. Lamoreaux, John Donald Leighton, Melvin H. Lill, Harrison T. Price

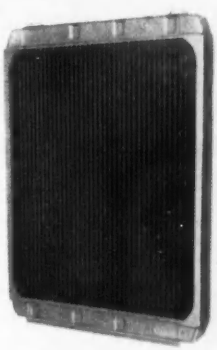
Milwaukee Section

Robert J. Hackett, Hugh Gerald Lautner, Robert L. Lawler, William Van Werkhoven

Continued on page 125

Young *Radiator cools Engine Jacket Water for High-Powered Diesels*

These powerful White tractors pull refrigerated trailers cross country. Rugged terrain and torrid deserts are taken in stride by these rugged Young Radiators. Our Light-Weight Stamped Tank Radiators are specially fabricated, and have *exclusive Double Lock-Seam construction.* Electronic lock-soldering of headers and tubes provide a more positive, surer construction and a stronger radiator . . . takes more stress . . . gives longer service than radiators unable to offer these features. Write or phone Young to discuss your Heat Transfer problems. No obligations, of course.



Young radiators have extra built-in strength

"Young Radiators are used where the going is tough!"

Write Dept. 119-C for Catalog 148A.

Young RADIATOR COMPANY
RACINE, WISCONSIN
Creative HEAT TRANSFER ENGINEERS
Executive Office: Racine, Wisconsin, Plants at Racine, Wisconsin, Mattoon, Illinois

Behlen Delivers Heavy, Bulky Loads Promptly... Using The Spicer Presto-matic

Behlen buildings are unique. They incorporate the firm's own frameless metal design and utilize many new developments to obtain a wide variety of applications. The design incorporates a system of channel ridges, or deep corrugations, to give unusual rigidity to metal panels and make possible great strength.

Almost cat-like agility — that's what Behlen Manufacturing Company's powerful Diamond T 923 F's need, in order to thread their way in and out of construction sites. Only the most dependable equipment can be considered — for the Behlen building business is booming, and split-second delivery schedules are absolutely necessary. Down-time is out!

That's why Behlen ordered the Spicer Presto-matic Truck Transmission System in their newest purchase from Diamond T Motor Truck Company.

Presto-matic is a semi-automatic truck transmission system that takes the effort out of driving by eliminating the clutch pedal — while also providing maximum fuel economy, minimum maintenance and greater safety for driver and equipment.

Write today for free illustrated booklet containing complete information on the operation and advantages of the Spicer Presto-matic Truck Transmission System.

DANA Spicer

DANA CORPORATION • Toledo 1, Ohio

DANA PRODUCTS Serve Many Fields:

AUTOMOTIVE: Transmissions, Universal Joints, Propeller Shafts, Axles, Powr-Lok Differentials, Torque Converters, Gear Boxes, Power Take-Offs, Power Take-Off Joints, Clutches, Frames, Forgings, Stampings.

INDUSTRIAL VEHICLES AND EQUIPMENT: Transmissions, Universal Joints, Propeller Shafts, Axles, Gear Boxes, Clutches, Forgings, Stampings.

AVIATION: Universal Joints, Propeller Shafts, Axles, Gears, Forgings, Stampings.

RAILROAD: Transmissions, Universal Joints, Propeller Shafts, Generator Drives, Rail Car Drives, Pressed Steel Parts, Traction Motor Drives, Forgings, Stampings.

AGRICULTURE: Universal Joints, Propeller Shafts, Axles, Power Take-Offs, Power Take-Off Joints, Clutches, Forgings, Stampings.

MARINE: Universal Joints, Propeller Shafts, Gear Boxes, Forgings, Stampings.

Many of these products manufactured in Canada by Hayes Steel Products Limited, Merritton, Ontario.

Applications Received

Continued

Montreal Section

Claude De Guise, Charles E. Senecal.

New England Section

Donald E. Jenks, Newton B. Perkins

Northern California Section

Donald A. Fraser, Nick Paul Jannakos, Fred Robert Schroeder

Northwest Section

Roy E. Rodman

Ontario Section

Norman H. Bell, William Howard Brokenshire, Nicholas G. Grabb, Donald C. Hubble, Paul G. Ingram, Kazimierz Korsak, N. D. Morgan, Fred Simon, Norman E. Thompson

Philadelphia Section

Leonard L. Berkan, Joseph P. Bernert, Jr., Griffith Bowen, Alwynne E. Clemmer, Robert J. Fritz, Jess William Oren, 3rd, Thomas John Rhodes, Joseph B. Solly.

Pittsburgh Section

Kenneth C. Herriott, William F. Hughes, B. Natarajan, Alan Peter Terrile

St. Louis Section

Arthur L. Roux

Salt Lake Group

Charles C. Burres

San Diego Section

Ray Beenstock, Albert C. Busche, Jr., Arthur Ross Campbell, Robert L. Clark, Bruce S. J. Jaeschke, George D. Johnson, Kenneth V. Lawson, Warren Lyle Rath, Jr., F. Q. Wilson

South Texas Group

John A. Buster, Jr., Cipriano Gonzalez, John D. Tosh

Southern California Section

William F. Bradley, Jose Gonzales, Harold N. Johnson, Ralph M. Kerstner, James N. Rauen, Donald S. Swayngim

Southern New England Section

Dr. Alan E. Ardis

Texas Section

Wilder B. Bishop

Texas Gulf Coast Section

Joseph D. Koza, William Bernard Nelson, Jr., Edward D. Shannon

Virginia Section

James Henry Bickerstaff, Jr.

Washington Section

Gabriel D. Boehler

Williamsport Group

Gunter Wilhelm Maybach

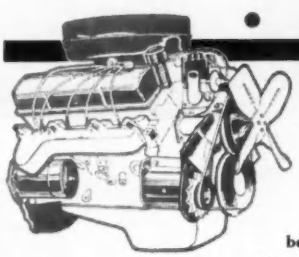
Outside of Section Territory

William A. Best, Robert A. Cohill, Herschell W. Dalton, Robert G. Ellis, S. Warren Kaye, Millard J. Kyle, Walter L. Lichtenberger, George E. Nichols, Leonard Pierce, Jr., Samuel E. Robinson, Jr., William P. Tolbert, Jr., F. G. Varabeau, Cyril William Von Fumetti

Foreign

Franco Autelli, Italy; Giorgio Geddes da Filicaia, Italy; Piet Olyslager, Holland; A. J. Schilling, France; Junzo Uozumi, Japan; S. Venkatachalam, India

JOHNSON *tappets*



***for all engine applications**

All of the engineering and manufacturing effort at Johnson Products goes into producing a better tappet. Continual experimentation and exacting quality control make JOHNSON TAPPETS worthy of your consideration. Only proven materials, covering a range of hardenable iron, steel, and chilled iron of various alloys, are used in JOHNSON TAPPETS. These tappets are successfully used in jobs ranging from light duty to the most severe, punishing applications. Serving all industry that employs internal combustion and diesel engines.

Johnson TAPPETS

"tappets are our business"

JOHNSON JP PRODUCTS

MUSKEGON, inc. MICHIGAN

SERVICE
IN STAINLESS STEEL

"FLIGHT OF PROGRESS"
a stainless steel sculpture by Robert Edward Hamilton

In the past 12 months 91% of all orders for J&L stainless steel bars were shipped, *at least* in part, within 24 hours.

That's service!

The key to such service is a simple one: Complete and balanced inventories at the Mill *and* at strategically located Service Centers only hours from *your* plant or warehouse.

With the most modern flat rolling facilities in the industry now in operation at Louisville, Ohio, J&L is now giving the same service on flat rolled products that fabricators and warehouses have been getting on J&L bars and wire.

Whether you need stainless sheet, strip, bar or wire for your production line or your warehouse customers, *you can get it faster from J&L.*

Plants and Service Centers:
Los Angeles • Kenilworth (N. J.) • Youngstown • Louisville (Ohio) • Indianapolis • Detroit

J&L
STAINLESS
SHEET • STRIP • BAR • WIRE

Jones & Laughlin Steel Corporation • STAINLESS and STRIP DIVISION • Box 4606, Detroit 34

"VITON"* COMPOUNDS SEAL AT NEW TEMPERATURE HIGHS

*Trademark of
E.I. du Pont de Nemours & Co.

Bothered by seal failure, or packings breakdown because of high temperatures? IPC may have your answer.

A new fluorinated rubber, VITON*, now solves sealing problems with a temperature range from —65° to over 600° F. Carefully controlled, these IPC VITON* packings and seals eliminate the punishing effects of temperature.

Why not ask IPC for a survey of your particular problem. Experience is priceless and IPC has pioneered in the use of VITON* for high temperature applications.

Custom designed . . . for your application.

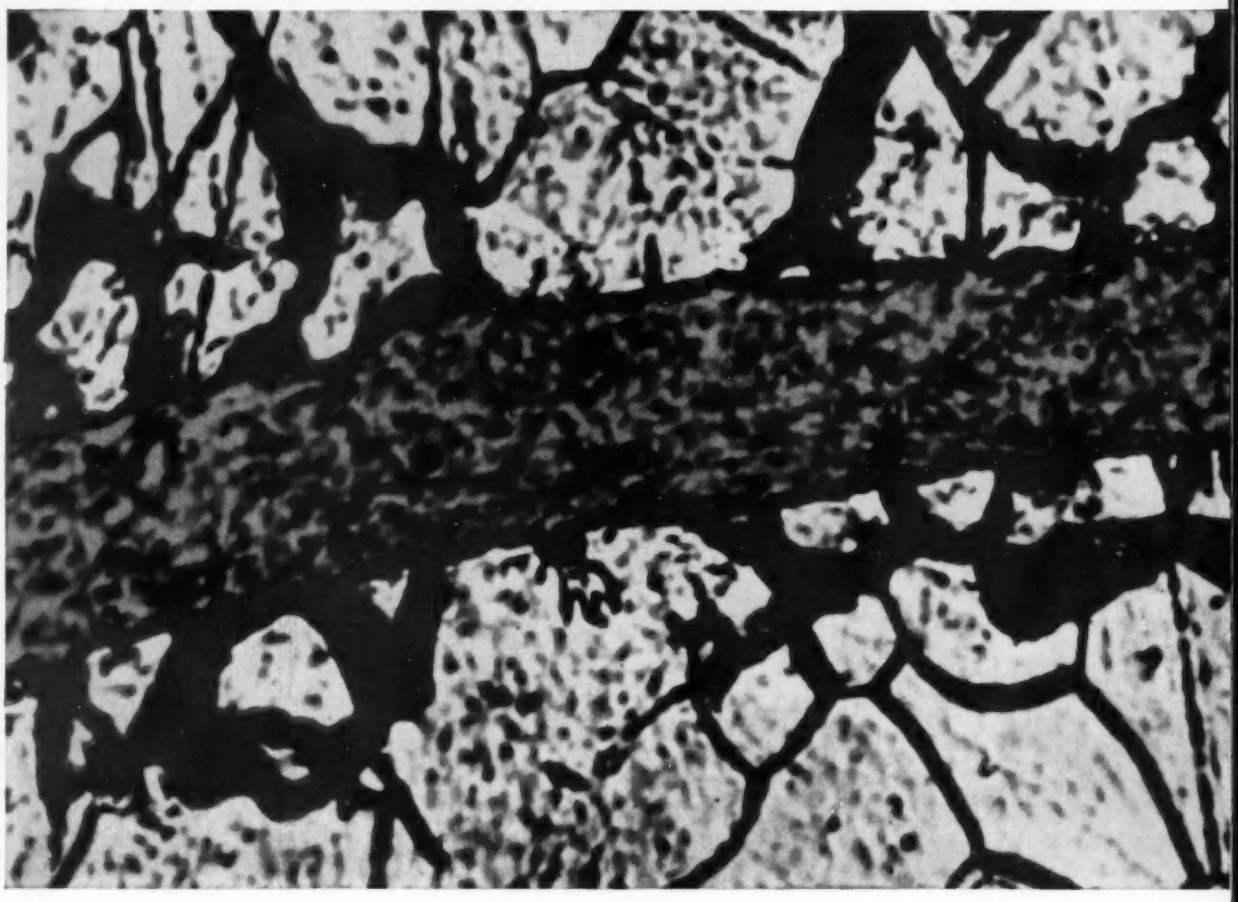
OIL SEALS
PACKINGS
PRECISION MOLDING

IPC

INTERNATIONAL PACKINGS CORPORATION

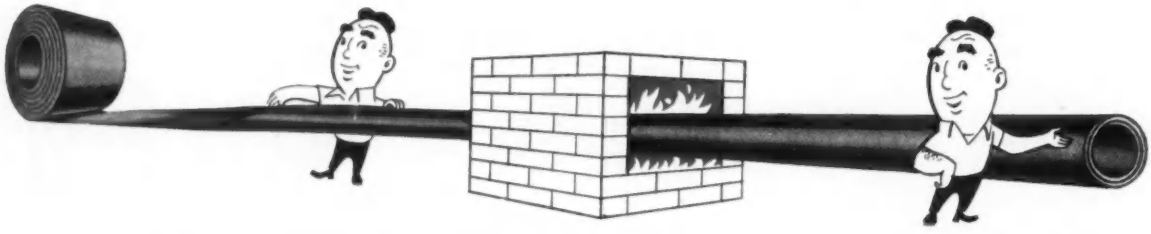
Bristol, New Hampshire

WHY BUNDY LEADS IN MASS-FABRICATION:

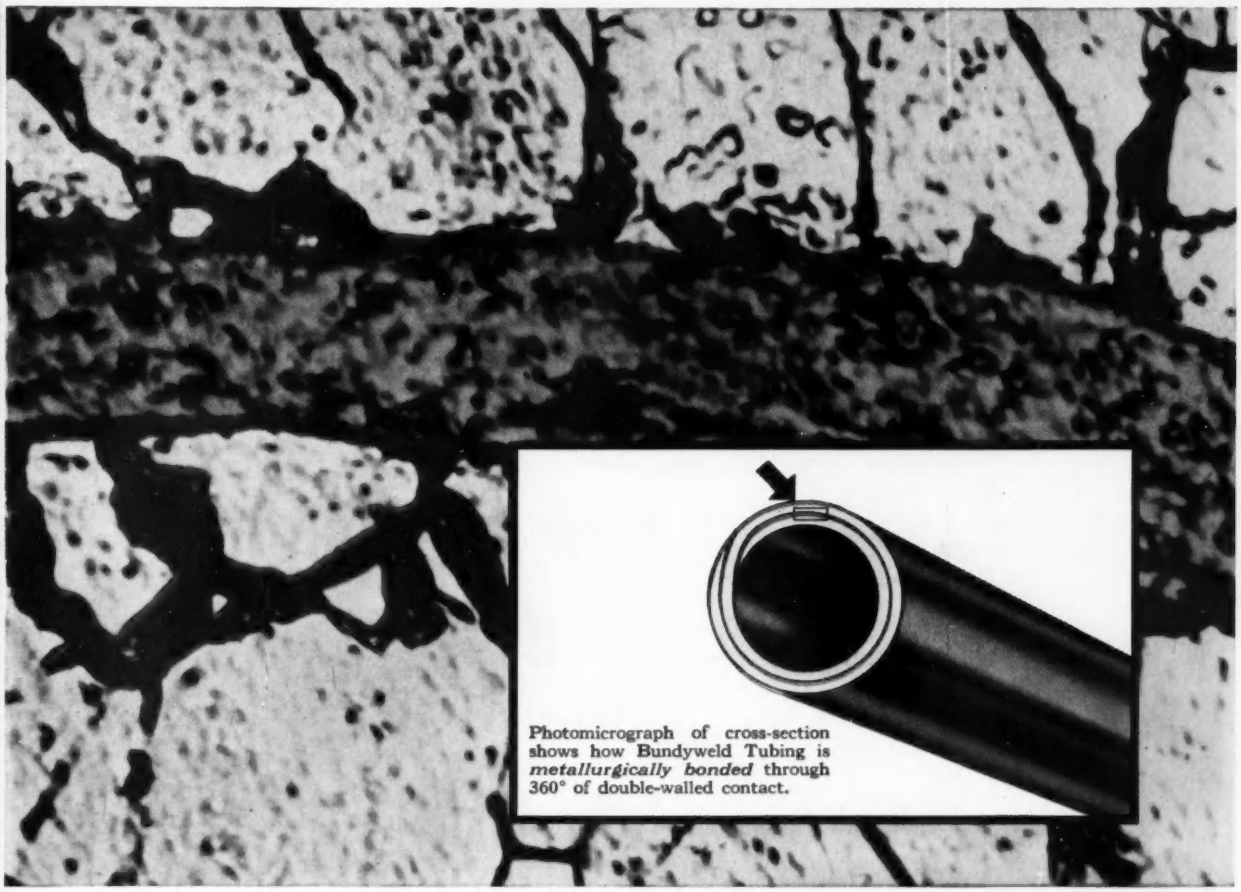


COPPER BRAZING...Another reason why

And Bundyweld can be mass-fabricated even in the most complex shapes—at a low unit-cost which results from three Bundy advantages:



Bundyweld starts as a single strip of copper-coated steel. Then it's continuously rolled twice around laterally . . . into a tube of uniform thickness, and passed through a furnace where copper coating fuses with basic steel. Result: Bundyweld Tubing—double-walled, beadless, metallurgically bonded through 360° of wall contact.


Photomicrograph of cross-section shows how Bundyweld Tubing is *metallurgically bonded* through 360° of double-walled contact.

Bundyweld prevents hydraulic leakage

This tubing was passed through a furnace where its copper coating *fused* permanently with base steel. It's just one of three reasons why Bundy® leads in the modern art of mass-fabrication.

Bundyweld Tubing® is copper-brazed to stay *leak-proof by test*. It stands up through brutal shock and punishing vibration . . . still handles high-pressure hydraulics with perfect safety. No wonder Bundyweld is used on 95% of today's cars, in an average of 20 applications each.

Free design service is yours at Bundy. Engineers famous for solving tricky tubing problems will work with you at any stage in the creation of a product; help you get parts at lowest unit cost.

Expert fabrication service is another Bundy specialty. From multiple-bend fuel lines to tiny oiler tubes, skilled technicians will turn out parts to your specifications; deliver them on time, ready to use.

Find out how it pays to check *first* with Bundy on any tubing problem. Call, write or wire us today!

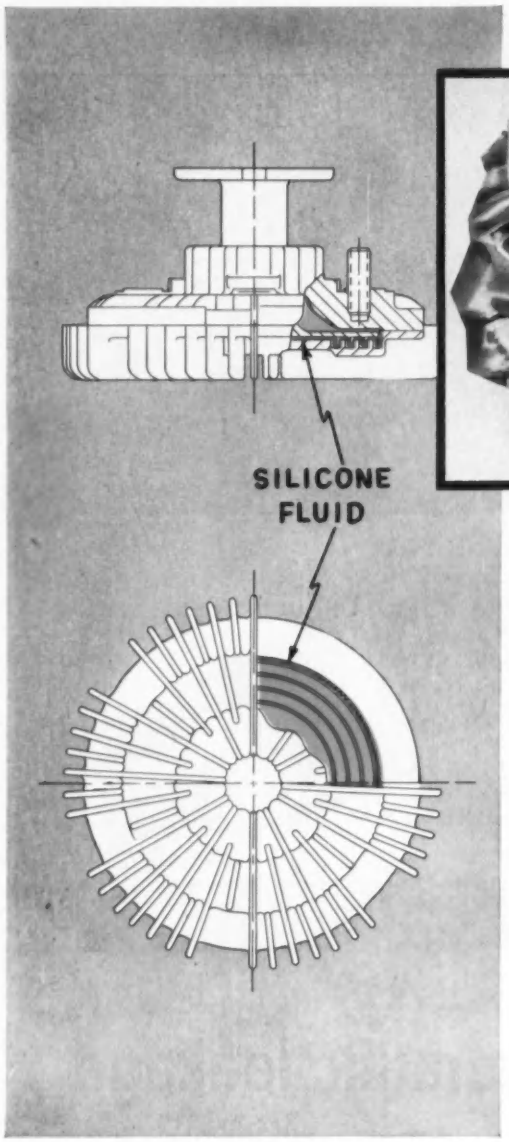
BUNDY TUBING COMPANY • DETROIT 14, MICHIGAN

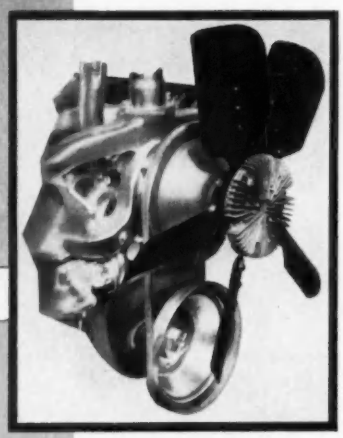
WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING • AFFILIATED PLANTS IN AUSTRALIA, ENGLAND, FRANCE, GERMANY, AND ITALY

There's no real substitute for

BUNDYWELD® TUBING

Bundyweld and Bundy specialty tubings are sold through distributors in principal cities





FAN DRIVE IMPROVES COOLING, CUTS FAN NOISE, INCREASES USEABLE HORSEPOWER

Designed to use Dow Corning silicone fluid for maximum efficiency and reliable performance, the Eaton Viscous Fan Drive makes it possible to increase cooling capacity at low speeds, or at idle, through the use of larger fans or higher fan-to-engine speed ratios. Engineered to limit speed of fan in the range of 30% to 60% of top engine speed, the Fan Drive reduces noise at cruising speeds and cuts demand on the power plant, thus making more horsepower available for other needs. The Eaton Viscous Fan Drive is one of a number of automotive accessories made by Eaton Manufacturing Company.

How to design for greater reliability with SILICONE FLUIDS

Where reliable, uniform performance over long periods of time and under widely differing conditions is required, Dow Corning silicone fluids excel. Dow Corning fluids are exceptionally resistant to oxidation — do not evaporate, thicken or thin out. They retain near-constant viscosities and show little change with varying temperature. Resistance to breakdown under shear is exceptional . . . these fluids are noted for their uniform damping, hydraulic, and torque transmission properties. As a result, they are specified more and more for long-term, reliable and uniform performance. For further information on properties and typical applications, send for the new *Engineering Guide to Silicone Fluids*, or talk with the technical representatives in our nearest branch office.

FREE!

Engineering Guide to Silicone Fluids

Please send me "Engineering Guide to Silicone Fluids"

Name

Company

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first in silicones

Dow Corning CORPORATION

MIDLAND, MICHIGAN

ATLANTA • BOSTON • CHICAGO • CLEVELAND • DALLAS
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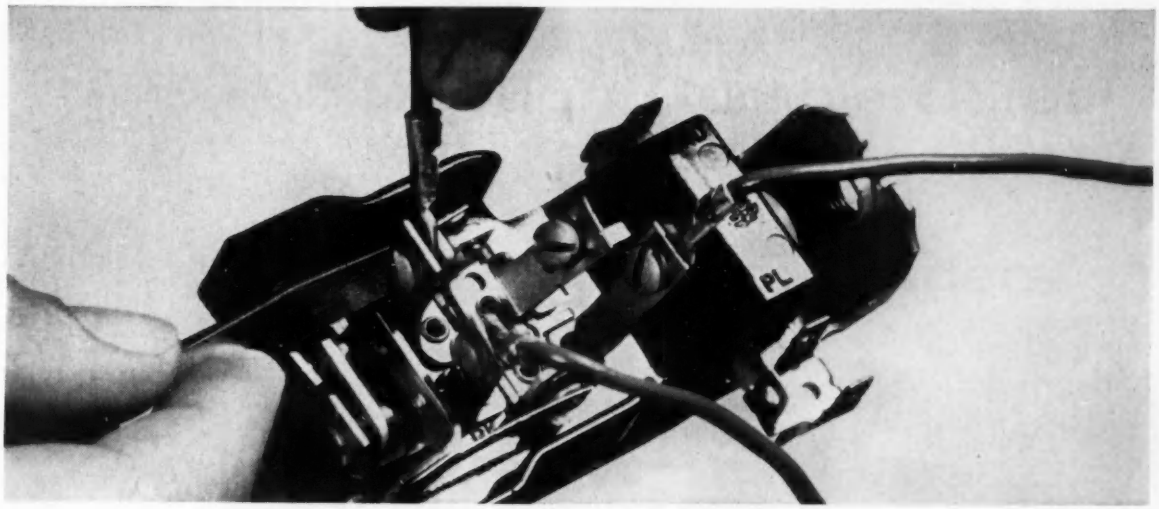
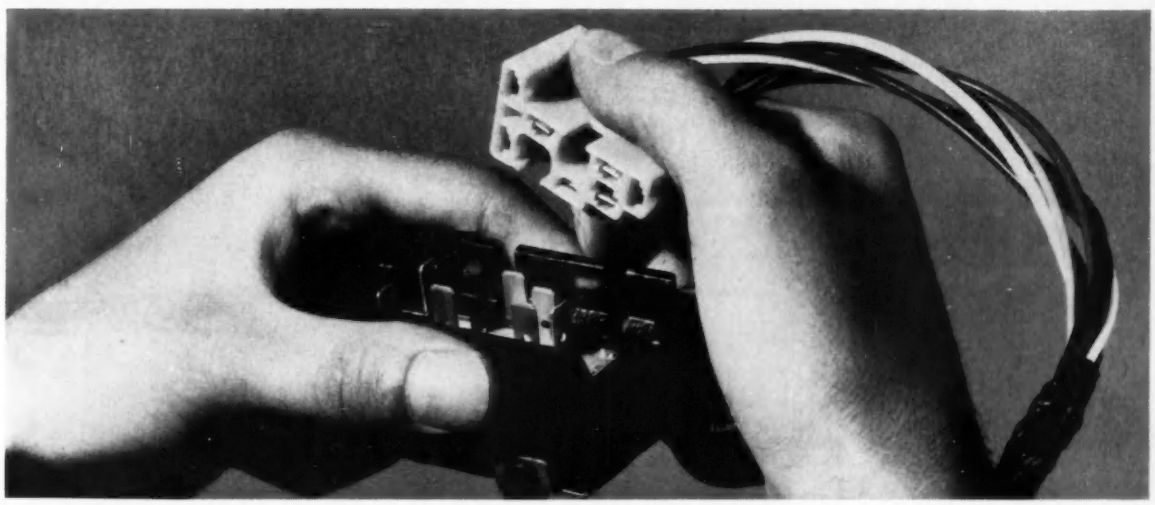


SLOW / *All these movements*



SWIFT / *can be reduced to one!*

One simple movement can connect two, three, five—up to eight different electrical circuits. Automakers prefer the Packard Electric idea of "Snap Fast" connectors because they speed wiring installations, save pennies per car. And these multiple-connection, self-insulating units assure accuracy, too. Since they can't be improperly installed, they eliminate the danger of assembly-line fires or other damage which often result from mistakes in single-terminal installations.

Designing time-saving, high-quality wiring systems and supplying them in large quantities is a long-time habit with Packard Electric. Many manufacturers prefer having one source, one responsibility, one transaction for their electric cable needs. And they find Packard engineering consultation helpful, too. Packard Electric maintains offices in Detroit, Chicago, and Oakland, California.

Packard Electric

Warren, Ohio GM GENERAL MOTORS

"Live Wire" division of General Motors

STAINLESS STEEL SAYS "NO" TO SCRATCHES!

Old stuff? Perhaps, but it always bears repeating. For it's worth remembering that stainless steel not only resists scratching but is also resistant to rust and corrosion, is extra strong and doesn't peel. What's more it's beautiful—and it *stays* beautiful.

That's why the slogan, "Make it better, make it stainless," is as meaningful today as ever. Bear in mind, too: The very finest stainless steels are made with Vancoram Ferro Alloys.

Producers of alloys, metals and chemicals

VANCORAM

VANADIUM CORPORATION OF AMERICA

420 Lexington Ave., New York 17, N. Y.
Chicago • Cleveland • Detroit • Pittsburgh

Tough, Durable Cores

every time with

Foundrez Resin Core Binders

Photos taken at Florence Pipe Foundry & Machine Co., Florence, N. J.

Volume production of heavy castings demands that the cores used by Florence Pipe Foundry & Machine Company stand up under rough handling. Florence secures the high tensile strength and hardness needed in these cores by using RCI FOUNDREZ 7100 series resin binders in their molding sand.

These water dispersible phenol-formaldehyde core binders are especially formulated for use where baking time is at a premium. In addition they possess higher hot strength and slower collapsibility than either core oils or urea-formaldehyde binders.

These resins are used in conventional core sand mixtures containing cereal binders and water. Only half as much FOUNDREZ as regular core oil is required to produce equivalent core handleability. Reichhold's FOUNDREZ 7100 series includes:

Foundrez 7101 — a high solids binder compounded for foundries where core gas is a problem. Extremely effective in producing cores with high strength and hardness.

Foundrez 7102 — formulated for very rapid baking schedules, this binder provides excellent green strength with a minimum of cereal binder.

Foundrez 7103 — features easy collapsibility and a low viscosity which permits ready mixing.

Foundrez 7104 — combines a high degree of stability with high tensile strength. Resultant cores are extremely moisture resistant — may be stored for long periods without fear of moisture pickup.

For complete technical data on the FOUNDREZ 7100 line write Reichhold — ask for Bulletin F-1-R.

Creative Chemistry . . .
Your Partner in Progress

RCI

REICHHOLD

FOUNDRY PRODUCTS

FOUNDREZ—Synthetic Resin Binders
COROVIT—Self-curing Binders • coRCIment—Core Oils

REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N. Y.

Another exclusive K&E *development...*

With new PHOTACT® Polyester Films you can make second originals—USING ORDINARY PAPER DEVELOPER

Available in 3 types:
PHOTACT Polyester Film, Contact — 409
PHOTACT Polyester Film, Direct Positive — 411
PHOTACT Polyester Film, Projection — 419
. . . all three with excellent drafting surface on both sides.

Now, for the first time, you can make photographic second originals *on film* without the fuss and bother of using special, short-lived, expensive developers. With new PHOTACT Polyester Films your regular paper developer does the job perfectly. Think what that means in terms of lower inventory – less cost – simpler operation.

With these new films you get all these other advantages . . .

. . . **Blacker blacks,** because PHOTACT film has a higher silver concentration than comparable film.

. . . **Durability,** wrinkle-proof – you can actually crumple a drawing on new PHOTACT Polyester Film into a ball, smooth it out, and still make a perfect reproduction.

. . . **Won't yellow** with age – or from repeated trips through the machine.

. . . **Quick drying** because these films are virtually waterproof.

. . . **Faster prints** due to greater transparency.

. . . **Better than original copy** – reproducibles from old yellowed drawings drop out stains, creases – strengthen detail.

These exceptional new films are part of a complete line by K&E – specialists in reproduction films, papers and cloths. See them now at your K&E dealer's. Or send in the coupon below for free samples and literature.

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Send me free samples and literature on new PHOTACT Polyester Films:
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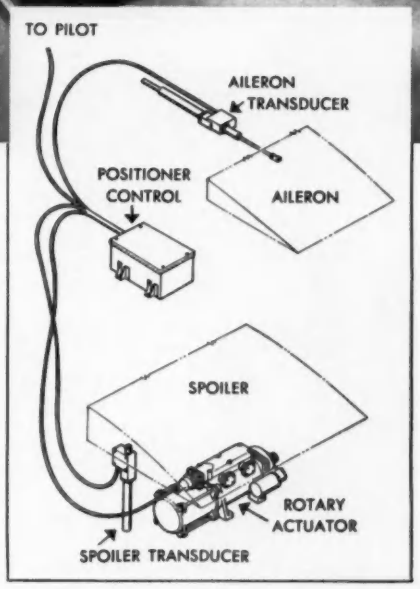
Advanced electro-mechanical systems

AiResearch Spoiler Servo Control System for Canadair's CL-28 and CL-44



A substantial increase in aileron effectiveness is achieved by the AiResearch Spoiler Servo Control System which augments the function of the aileron by increasing the rate of roll of the aircraft. Full spoiler surface travel is achieved in 0.5 seconds by electromagnetic clutching of the 4 H.P. power servo.

The added control surface of the Spoiler Control Servo System operates on the inboard side of each aileron. This AiResearch electro-mechanical system automatically synchronizes the spoiler control surface to move simultaneously with the aileron by utilizing a magnetic amplifier and position transducers in the closed loop servo system.

This new Spoiler Control System is but one of the many types of electro-mechanical systems developed and manufactured by AiResearch. Other recent examples include radar antenna positioning equipment, magnetron and Klystron tuning devices, and safe-arm mechanisms for missile igniting.

The company's more than 20 years of experience in the development and manufacture of electro-mechanical equipment extends into aircraft, ground handling, ordnance and missile systems of all types. AiResearch capability and system responsibility can meet your specific electro-mechanical requirements. Your inquiries are invited.

ENGINEERING REPRESENTATIVES: AIRSUPPLY AND AERO ENGINEERING, OFFICES IN MAJOR CITIES

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

MAN'S FIRST SPACE COMMUNICATION STATION

On 12 October 1958, an historic event took place. A group of Space Technology Laboratories' engineers at Cape Canaveral, Florida, transmitted radio signals far out into space to the NASA/Air Force Pioneer space probe vehicle. The tiny receiver and transmitter in the Pioneer relayed these same signals to the Space Technology Laboratories' group at Manchester University, England. • This significant experiment promises, like those earlier achievements of Morse, Bell, and Marconi, to pave the way for the use of space vehicles to relay information to and from points on earth. One day the entire world will view televised events as they happen. • Future experiments of this kind will undoubtedly assist mankind in his search to understand, use, and benefit from his knowledge of space phenomena. • Scientists and engineers whose interests and abilities enable them to contribute to these developments are invited to join our technical staff.

Space Technology Laboratories, Inc. P.O. BOX 95001, LOS ANGELES 45, CALIFORNIA

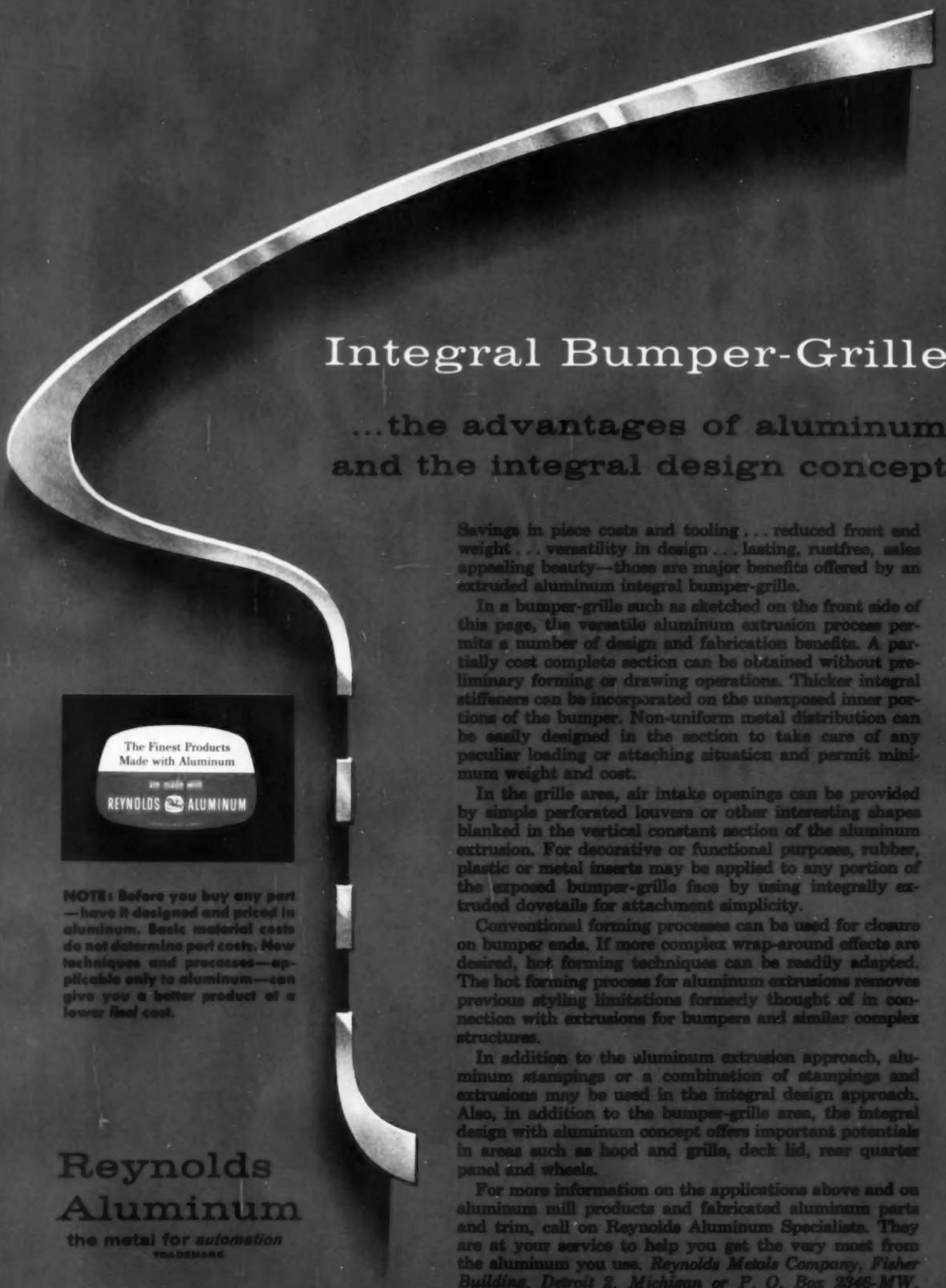
The 250′ radio telescope pictured here is operated by a team of British scientists under the direction of Professor A. C. B. Lovell, University of Manchester, whose cooperation contributed materially to making this achievement possible.

Integral Design with Aluminum
by Reynolds

Integral Aluminum Bumper-Grille

The Finest Products Made with Aluminum are made with REYNOLDS ALUMINUM

...a weight and cost saving design concept for tomorrow's fine cars



Integral Bumper-Grille

...the advantages of aluminum and the integral design concept

Savings in piece costs and tooling . . . reduced front end weight . . . versatility in design . . . lasting, rustfree, sales appealing beauty—those are major benefits offered by an extruded aluminum integral bumper-grille.

In a bumper-grille such as sketched on the front side of this page, the versatile aluminum extrusion process permits a number of design and fabrication benefits. A partially cost complete section can be obtained without preliminary forming or drawing operations. Thicker integral stiffeners can be incorporated on the unexposed inner portions of the bumper. Non-uniform metal distribution can be easily designed in the section to take care of any peculiar loading or attaching situation and permit minimum weight and cost.

In the grille area, air intake openings can be provided by simple perforated louvers or other interesting shapes blanked in the vertical constant section of the aluminum extrusion. For decorative or functional purposes, rubber, plastic or metal inserts may be applied to any portion of the exposed bumper-grille face by using integrally extruded dovetails for attachment simplicity.

Conventional forming processes can be used for closure on bumper ends. If more complex wrap-around effects are desired, hot forming techniques can be readily adapted. The hot forming process for aluminum extrusions removes previous styling limitations formerly thought of in connection with extrusions for bumpers and similar complex structures.

In addition to the aluminum extrusion approach, aluminum stampings or a combination of stampings and extrusions may be used in the integral design approach. Also, in addition to the bumper-grille area, the integral design with aluminum concept offers important potentials in areas such as hood and grille, deck lid, rear quarter panel and wheels.

For more information on the applications above and on aluminum mill products and fabricated aluminum parts and trim, call on Reynolds Aluminum Specialists. They are at your service to help you get the very most from the aluminum you use. *Reynolds Metals Company, Fisher Building, Detroit 2, Michigan or P. O. Box 2346-MW, Richmond 18, Virginia.*

The Finest Products Made with Aluminum are made with REYNOLDS ALUMINUM

NOTE: Before you buy any part—have it designed and priced in aluminum. Basic material costs do not determine part costs. New techniques and processes—applicable only to aluminum—can give you a better product at a lower *final* cost.

Reynolds Aluminum

the metal for *automation*

TRADEMARK

Watch Reynolds new TV shows—"WALT DISNEY PRESENTS" and "ALL-STAR GOLF"—every week on ABC-TV.

ENGINEERS–SCIENTISTS

Engineers and Scientists at Republic Aviation—with a turn for dry professional humor—say that they're asked to solve every problem of upper atmosphere and space flight with the factor

$$\sqrt{1-\frac{v^2}{c^2}}$$

This human application of the relativistic theory of space-time relationships is predicated on the conviction that the creative content of technological thinking can be immeasurably expanded and enriched—given a propitious environment.

That the environment at Republic *is* propitious, is evident from the results.

Engineers and scientists like it. They thrive on it. Technical ideas of a "revolutionary" character—rather than "evolutionary"—are appearing at a rate that exceeds the norm of even 5 years ago.

In every professional area—research, development, experimental engineering—*the goal is the same:*

TELESCOPING TIME

in terms of technological progress

▶ *in exotic propulsion systems for space operation—plasma propulsion...advanced nuclear power applications...*

▶ *in integrated electronic systems for flight vehicles to operate at every altitude*

▶ *in supersonic and hypersonic weapons systems, both manned and unmanned*

For an invigorating environment, where new ideas flourish, look at the range of opportunities at Republic

ELECTRONICS
Inertial Guidance & Navigation • Digital Computer Development • Systems Engineering • Information Theory • Telemetry-SSB Technique • Doppler Radar • Countermeasures • Radome & Antenna Design • Microwave Circuitry & Components • Receiver & Transmitter Design • Airborne Navigational Systems • Jamming & Anti-Jamming • Miniaturization-Transistorization • Ranging Systems • Propagation Studies • Ground Support Equipment

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PLASMA PROPULSION
Plasma Physics • Gaseous Electronics • Hypersonics and Shock Phenomena • Hydromagnetics • Physical Chemistry • Combustion and Detonation • Instrumentation • High Power Pulse Electronics

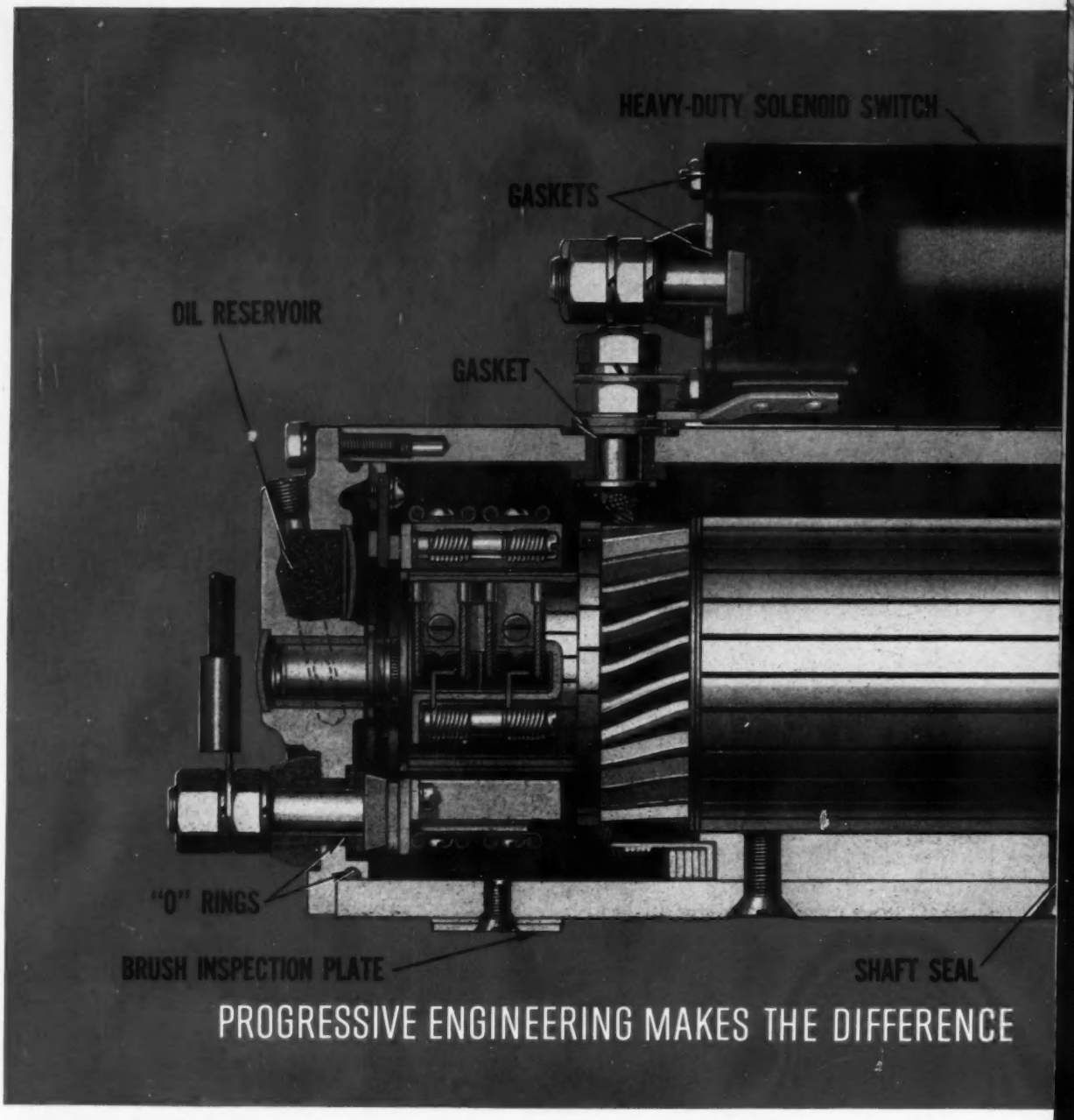
NUCLEAR PROPULSION & RADIATION PHENOMENA
Nuclear Weapons Effects • Radiation Environment in Space • Nuclear Power & Propulsion Applications • Nuclear Radiation Laboratories

A new $14,000,000 Research Center—to be completed this year—is part of Republic's far-ranging R&D programs aimed at major state-of-the-art breakthroughs in every flight regime and environment.

Send resume in complete confidence to:
Mr. George R. Hickman, Engineering Employment Mgr., Dept. 7C

REPUBLIC AVIATION

Farmingdale, Long Island, New York

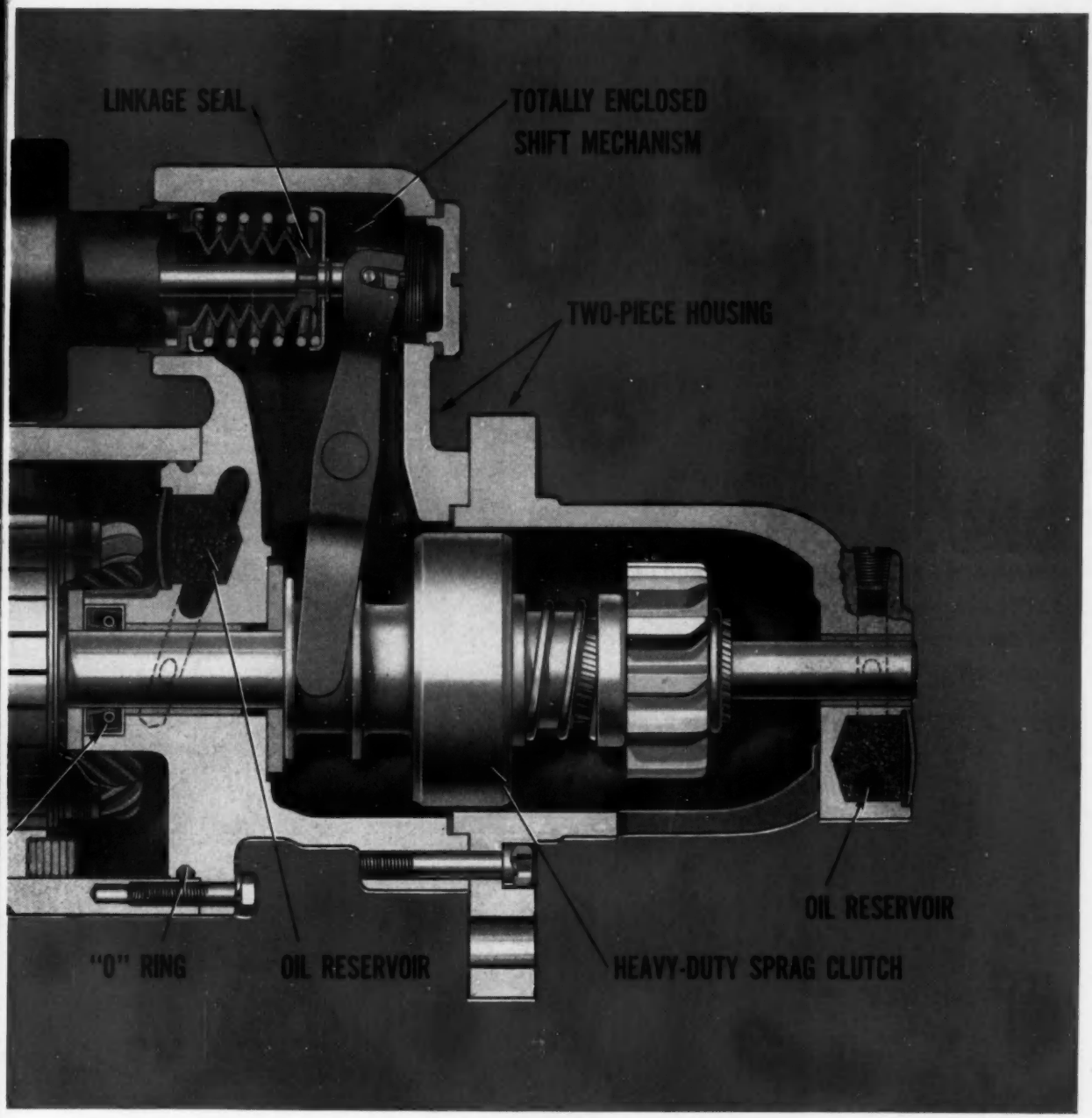


ANNOUNCING THE NEW DELCO-REMY TOTALLY

Delco-Remy now offers a completely new series of solenoid-operated, over-running clutch type heavy-duty cranking motors with the shift mechanism entirely enclosed. Special two-piece drive housings can be assembled to permit a total of 24 different solenoid positions with respect to motor mounting. New 50% longer brushes, together with sealing rings (optional) and large oil reservoirs (optional), assure extra-long operating time between overhauls. And Delco-Remy design features keep these heavy-duty cranking motors positively engaged until the engine starts. Engine manufacturers are invited to write directly to Delco-Remy for complete information and engineering assistance on the application of these new motors.

TOTALLY ENCLOSED DRIVE SHIFTING MECHANISM is protected against dirt, water, slush and ice. This enclosure plus the shaft seal and linkage seal also prevents transmission oil leakage.

TWO-PIECE DRIVE HOUSING DESIGN permits 24 different solenoid positions. Nose housings available in S.A.E. #2 and #3 mountings.



ENCLOSED HEAVY-DUTY CRANKING MOTORS

HEAVY-DUTY SOLENOID AND SWITCH provide positive pinion engagement and safely handle maximum starting current. Special seals increase contact life.

SPRAG CLUTCH DRIVE operates with non-chamfered ring gear. Pinion indexes on spiral spline, positively engages ring gear before power switches on, and does not become disengaged with sporadic engine firing.

HEAVIER BRUSH INSPECTION PLATES resist damage from use and handling—are sealed to prevent leakage to motor interior.

GENERAL MOTORS LEADS THE WAY—STARTING WITH

Delco-Remy

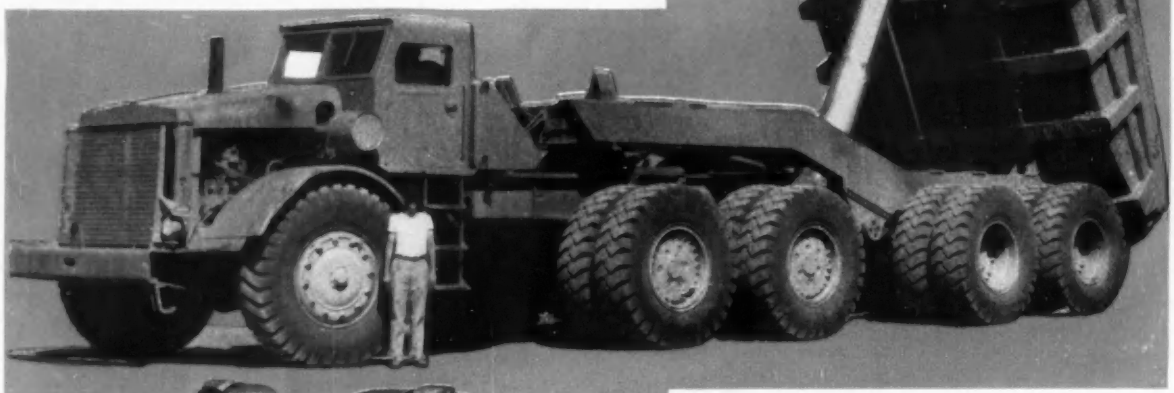
GM GENERAL MOTORS

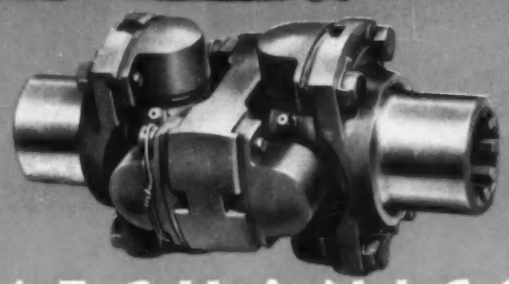
ELECTRICAL SYSTEMS

DELCO-REMY • DIVISION OF GENERAL MOTORS • ANDERSON, INDIANA

World's Largest Truck Uses Ten MECHANICS *Roller Bearing* UNIVERSAL JOINTS

Capable of hauling 165 tons of dirt at 35 miles per hour over rough roads, this huge truck stands 45 feet (over four stories) high. Its power transmission train must stand up under hour-after-hour, day-in-and-day-out of gruelling service and deliver hundreds of thousands of miles of trouble-free service. Because the MECHANICS JOINTS used drive through KEYS—instead of bolts—they withstand this type of punishment—that would shear off other types of fasteners.





MECHANICS
Roller Bearing BW
UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

They are designed with less parts and connections for easy assembly and servicing—smooth running balance—maximum strength with less weight—and long, trouble-free, safe operation. Rugged stamina is just one of the advantages you get when you specify MECHANICS JOINTS. Let Mechanics engineers help you design this and other competitive sales features into your product.

MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2022 Harrison Ave., Rockford, Ill.
Export Sales: Borg-Warner International
36 So. Wabash, Chicago 3, Illinois

The Inquiring Mind at Oldsmobile

no. 8 OF A SERIES

THE SOUND . . . AND THE JURY

The quiet, solid feeling inside the 1959 Oldsmobile results from patient testing by a highly specialized "jury"—experts in the field of sound analysis.

Unlike most other phases of automotive engineering, there are no instruments which measure the "annoyance" factor of sounds inside an automobile. Subjective, personal evaluation known as the "jury system" is the most important means of determining how quiet it is inside an Oldsmobile.

With the "jury system", several experienced engineers assemble in an acoustically treated room and listen to binaural tape recordings made inside a test car. Careful editing of the tape recording allows rapid side-by-side comparison between two different test conditions and eliminates reliance on memory since considerable time may elapse between actual tests. By pushing a button, each engineer casts a secret "vote" and then the tabulation of the results determines which test condition is superior.

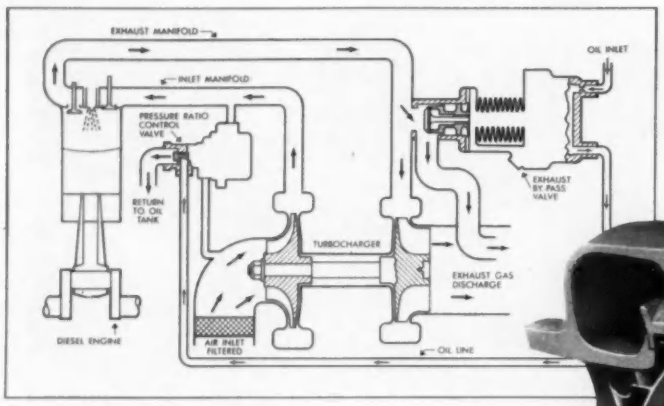
For the greatest possible accuracy, considerable care is taken making the recordings. Special microphones are placed at points corresponding to the passengers' ears. The recording equipment is in a specially equipped vehicle which follows the test car over a "ride road" that is carefully constructed to excite the vibrations and sounds that occur under normal driving conditions.

Quality, like quietness, is not accidental. It is the deliberate effort by Oldsmobile engineers to *design* quality into every automobile they produce. You'll like the 1959 Oldsmobile—with its solid Body by Fisher—it's the quietest car built! Experience this quality for yourself by visiting your local Authorized Oldsmobile Quality Dealer as soon as possible.

OLDSMOBILE DIVISION
GENERAL MOTORS CORPORATION

OLDSMOBILE **Where Quality is Standard Equipment!**

Most significant advances in turbocharging



Pressure ratio control valve

Exhaust by-pass valve

AiResearch Industrial Division has made these vital contributions to the diesel industry

- provides the most economical turbocharging of diesel engines 50 to 700 H.P....
- designed and manufactured the first successful air-cooled turbocharger...
- built the first pressure-ratio control system to keep the turbocharger operating at peak efficiency continuously...
- developed the "free vortex" principle to replace the vaned nozzle, substantially decreasing the cost of small turbochargers...
- uses compressors with exceptionally broad characteristics to give best efficiency over a wide range of engine operation...
- has delivered more than 20,000 turbochargers in the last five years...
- currently turbocharges more than six million horsepower in diesel equipment...
- sells turbochargers and turbocharger control systems to 21 major engine manufacturers.

Your inquiries are invited.

THE GARRETT CORPORATION

AiResearch Industrial Division

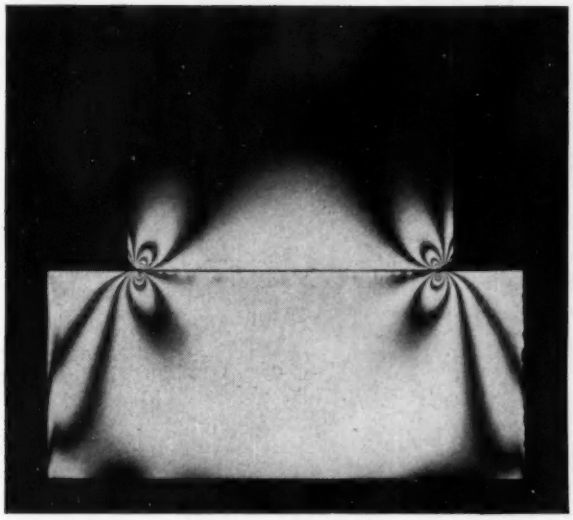
9225 South Aviation Blvd., Los Angeles 45, California

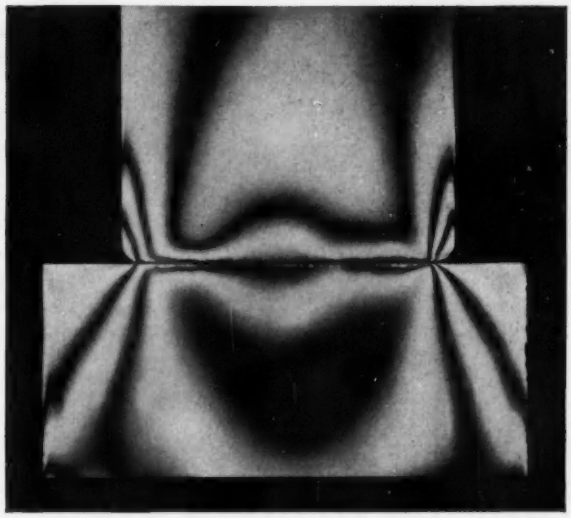
DESIGNERS AND MANUFACTURERS OF TURBOCHARGERS AND SPECIALIZED INDUSTRIAL PRODUCTS

One in a series of technical reports by Bower

BEARING BRIEFINGS

ROLLER BEARING LIFE AND CAPACITY LINKED TO STRESS DISTRIBUTION





These reproductions of photoelastic studies contain important evidence for every engineer and designer concerned with the performance and selection of roller bearings. In these photographs, the alternate dark and light areas, called fringes, indicate not only the magnitude of stress but also the stress distribution. The photographs were taken by Bower Research Engineers during a study of stress distribution in roller bearings.

The subjects represent rollers and raceways of two roller bearings under identical loads. The illustration at the left shows a roller of conventional design. The illustration at the right shows a Bower "Profiled" roller. That is, the roller is precision ground with a large radius generated along the body of the roller—a predetermined and controlled distance from each end.

The conventional roller photo (left) clearly shows how, under load, stress concentration builds up in and near the roller ends. This is called edge-loading. Such areas of concentrated stress are the breeding grounds for metal fatigue and eventual bearing failure.

In the photo of the "Profiled" roller (right) stress lines can be seen uniformly distributed across the whole length of the roller and raceway. There are no points of excessive stress concentration, consequently no starting points for early fatigue. Such a "Profiled" roller exhibits a great advantage in improved load carrying capacity, a most important bearing requirement.

Under actual operating conditions, Bower "Profiled" roller bearings show a considerably longer life at higher speeds and under greater loads than conventional roller bearings.

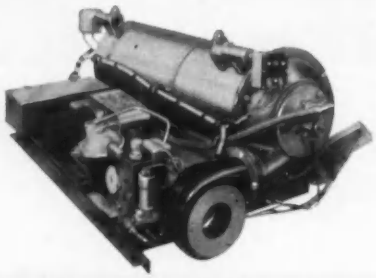
Because of this, and of other Bower features to be discussed in later technical reports, we suggest that you consider the advantages of Bower bearings in satisfying your future bearing requirements.

★ ★ ★ ★

Bower engineers are always available, should you desire assistance or advice on bearing problems. Where product design calls for tapered roller bearings or journal roller assemblies, Bower makes these also in a full range of types and sizes.

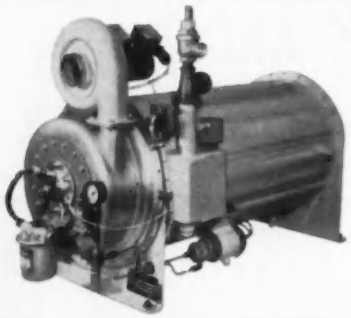
BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION — FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN



90,000 Btu/hr Janitrol liquid heater

for support vehicle comfort and cargo heating, windshield defrosting. Ideal for use on fire trucks, movers, weapons loaders, personnel carriers, in temperatures to −65° F.



500,000 Btu/hr Janitrol liquid heater

for portable structures, large vehicles, and for heating decontaminents and cleaning fluids on mobile ice removal units.

1,000,000 Btu/hr Janitrol liquid heater

for missile fuel transfer operations, large portable structures, airlifted equipment. Approximately 18″ in diameter, 47″ high, weight: 260 lbs.

reliable ground support liquid heat packages

Missile and aircraft support equipment builders use Janitrol *liquid* heater packages with little or no modification because they're designed for military applications. Meeting appropriate MIL specifications and fully qualified, they're available in outputs to 1 million Btu/hr. They provide any desired amount of heat up to rated output and automatically maintain constant temperatures.

As an example of acceptance, most Air Force crash-fire vehicles are equipped with one or more of these heaters, for engine, chemicals, cargo and crew space heating. Multi-fuel operation is standard, and they perform reliably in multiples for heat requirements which exceed the output of a single unit.

Ask your Janitrol engineering representative for a proposal for thoroughly proven ground support heating equipment.

Janitrol Aircraft Division, Surface Combustion Corporation, Columbus 4, Ohio.

JANITROL®

pneumatic controls • duct couplings & supports • heat exchangers
combustion equipment for aircraft, missiles, ground support

PROVED AND PREFERRED...

Timken-Detroit® Axles are the Accepted Standard!

Timken-Detroit Heavy-Duty Tandems Are First Choice With Big Off-Highway Operators!

These superior features make the difference:

"Cradle Ride" Suspension. Free ends of long, resilient springs float in axle spring guide brackets. This permits axles to articulate freely, compensating for road irregularities. Floating springs cradle the vehicle, materially reducing road shock and eliminating source of vehicle flutter. *The load is more stable . . . driving is easier, more restful, safer.*

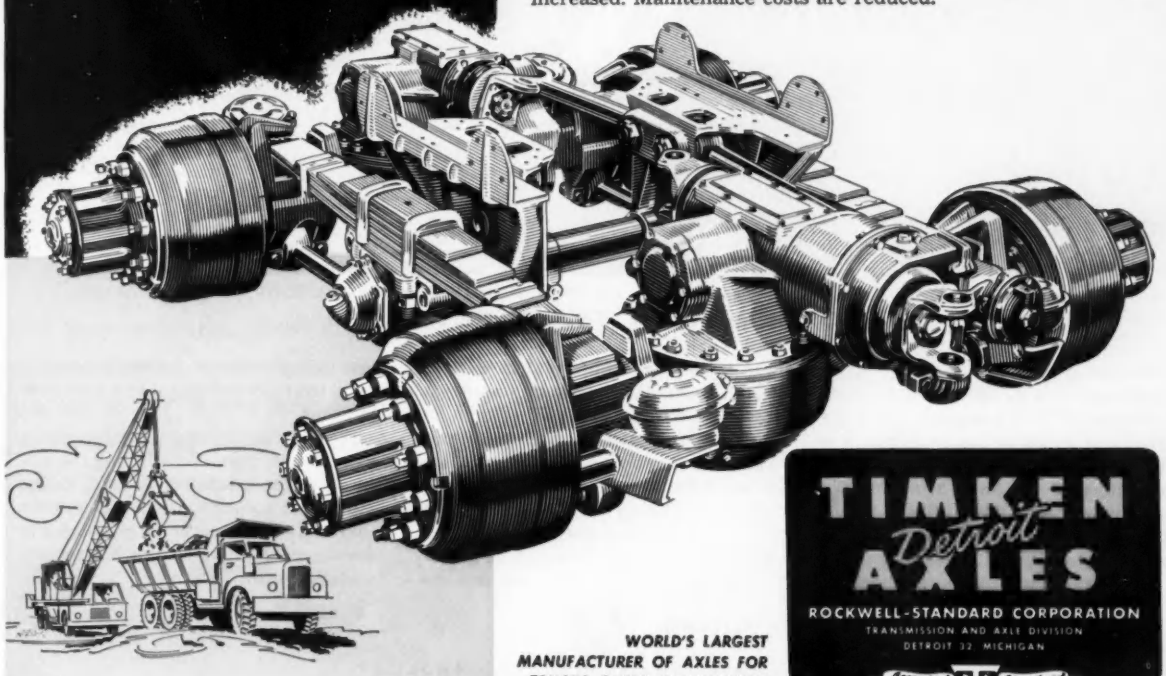
Hypoid Gears. Larger pinions and greater tooth contact give 30% more torque capacity, top efficiency and long life . . . *plus lower maintenance costs.*

Driver Controlled Inter-Axle Differential. Torque is divided equally between axles, yet wheels of one axle can turn faster or slower than wheels of other axle. This means both axles are always doing equal amounts of work. *Driving parts and tires last longer.*

Hot Forged Rectangular-Shaped Axle Housings. Rectangular shape, combined with full strength corner sections, provides the greatest strength with minimum weight and size. Welded-on bowl cover prevents leakage.

Torsion Flow Axle Shafts. More splines, plus greater root and body diameter, add extra strength.

Straight-Line Through Drive. Straight through drive eliminates all prop shaft angularity. Bearing and gear life is materially increased. Maintenance costs are reduced.



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The Accepted DA Standard
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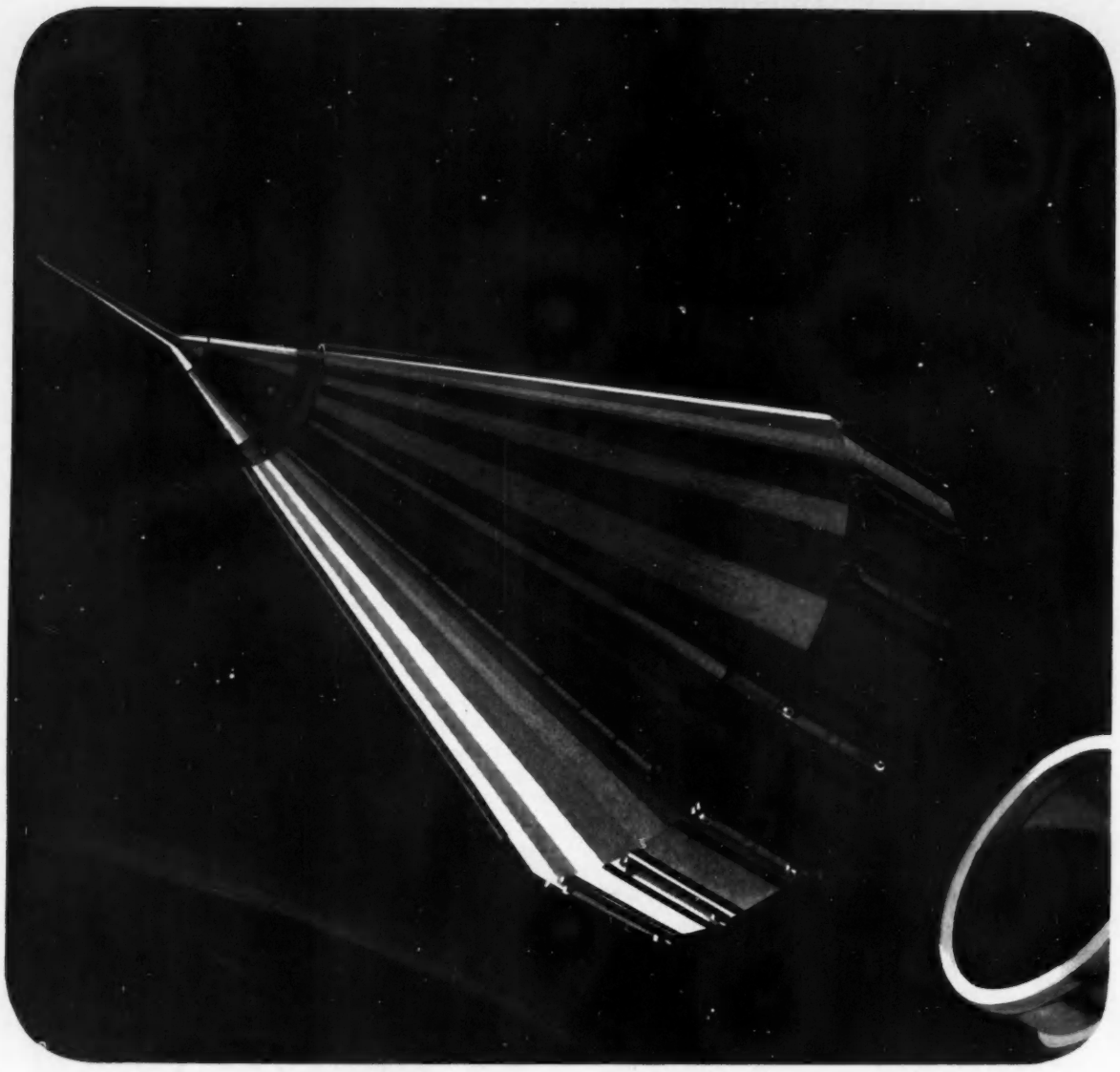
Products of **ROCKWELL-STANDARD** Corporation

NOTABLE ACHIEVEMENTS AT JPL...



PIONEERING IN SPACE RESEARCH

Another important advance in man's knowledge of outer space was provided by Pioneer III. This, like many others of a continuing series of space probes, was designed and launched by Jet Propulsion Laboratory for the National Aeronautics and Space Administration. JPL is administered by the California Institute of Technology for NASA.

During its flight of 38 hours, Pioneer III was tracked by JPL tracking stations for 25 hours, the maximum time it was above the horizon for these stations.

The primary scientific experiment was the measurement of the radiation environment at distances far from the Earth and telemetering data of fundamental scientific value was recorded for 22 hours. Analysis of this data revealed, at 10,000 miles from the Earth, the existence of a belt of high radiation intensity greater than that observed by the Explorer satellites.

This discovery is of vital importance as it poses new problems affecting the dispatch of future vehicles into space. The study and solution of such problems compose a large part of the research and development programs now in extensive operation at the Laboratory.

jpl

CALIFORNIA INSTITUTE OF TECHNOLOGY
JET PROPULSION LABORATORY
A Research Facility operated for the National Aeronautics and Space Administration
PASADENA, CALIFORNIA

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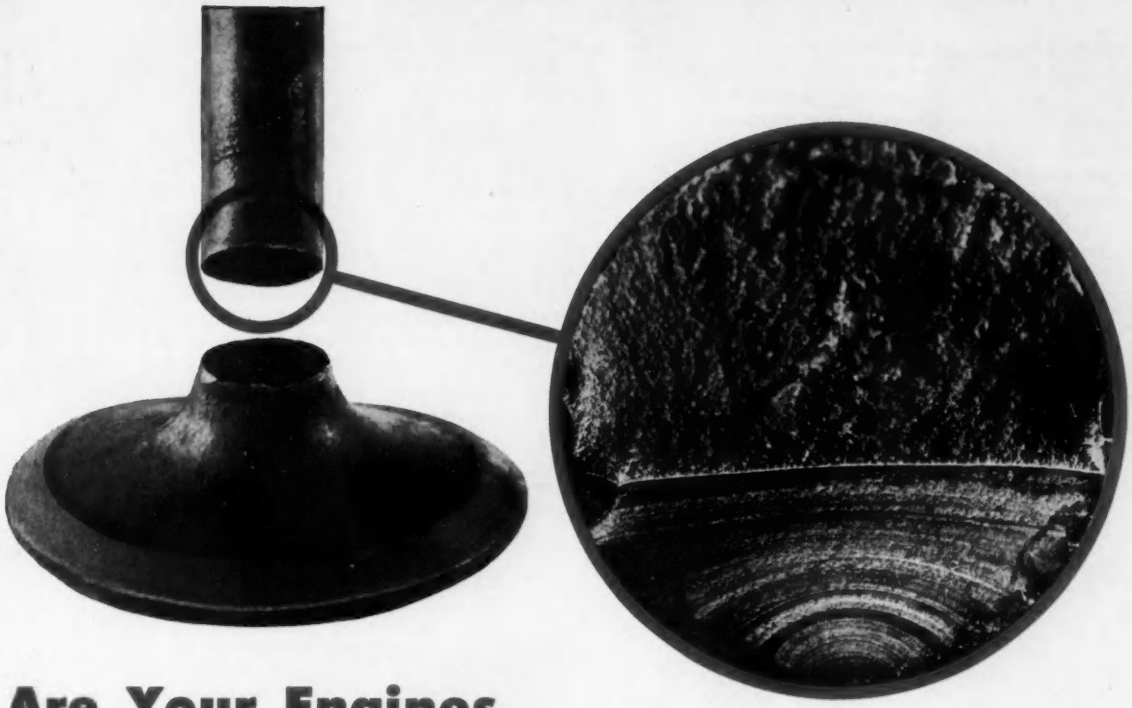
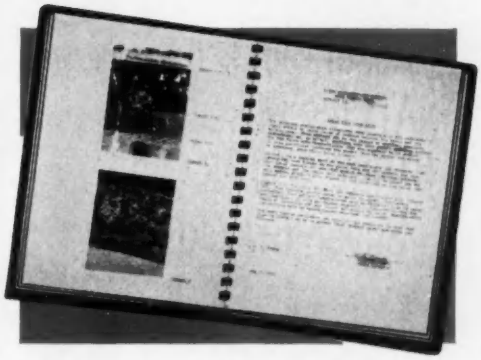


Are Your Engines Plagued by Failures Like This?

Eaton Engineers Can Help You Solve This Problem

The photographs above illustrate a typical fatigue-type failure caused by overstressing, in which fracture starts at the surface and, with repeated high stress, progresses to final break.

If you are an engine manufacturer and are having valve gear problems, Eaton engineers will be glad to consult with you and recommend procedures to help solve them. Or if you are designing new engines, perhaps our past valve experience can be valuable to you. Write, wire, or phone — there's no obligation.



Eaton Technical Reports are Available to Manufacturers

Eaton valve engineers will be glad to make a thorough study for you and furnish a complete technical report.

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BATTLE CREEK, MICHIGAN

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Failure of any part of a missile—be it the mighty Atlas, Jupiter or Thor—can mean failure of the mission. That's why the complex connections in the ducting systems of these and other missiles are silver brazed. These connections must stand up under 6,000 psi; they are tested to 12,000 psi.

In lines made to specifications by Flexonics Corporation, Maywood, Illinois, silver brazing joins a corrugated flexible pressure carrier, a braid sleeve and a coupling nipple—all of stainless steel; it permits joining all of these elements of the assembly without danger of annealing the pressure-carrying flex or the restraining braid as welding might do.

Assemblies designed for 6,000 psi operating pressure are required to withstand a 12,000 psi test and take four times their normal operating pressure before failure. They may also be required to pass a flame test in order to meet specifications.

The silver-brazed connections are used on hydraulic and pneumatic systems, fuel drain lines and vent tubes. Some of these applications involve rigorous service with extreme pressure shocks accompanied by sudden elevations of temperature, which may go from −60° to 400-600° F in a matter of seconds.

A more "high level" endorsement of Handy & Harman silver alloy brazing is not available. On the ground or in the air, the qualities of this remarkable metal joining method apply; strength, ease of production, cost, gas and liquid joint tightness to name a few. The entire brazing story is yours merely for the asking. Inquiries and metals-joining "problem exposure" may be addressed to Handy & Harman, 82 Fulton Street, New York 38, N. Y. We welcome the opportunity to work with you.

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HANDY & HARMAN

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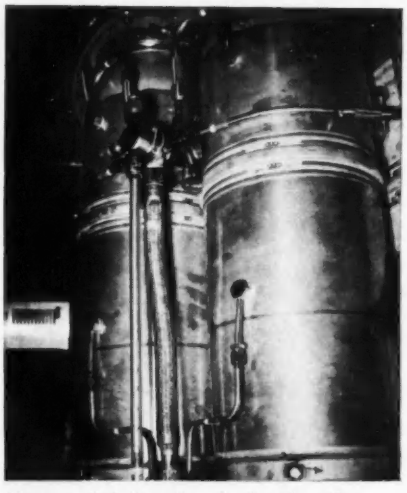
No Margin Here for joint failure!

Assemblies in ATLAS Missile **HANDY & HARMAN** Silver Brazed

Intercontinental Atlas missile being made ready for launching.



Close-ups of missile section, showing silver alloy brazed ducting assembly.

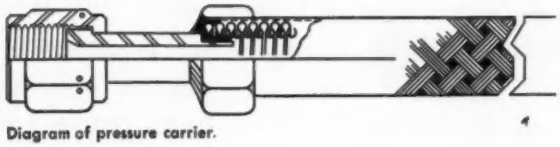
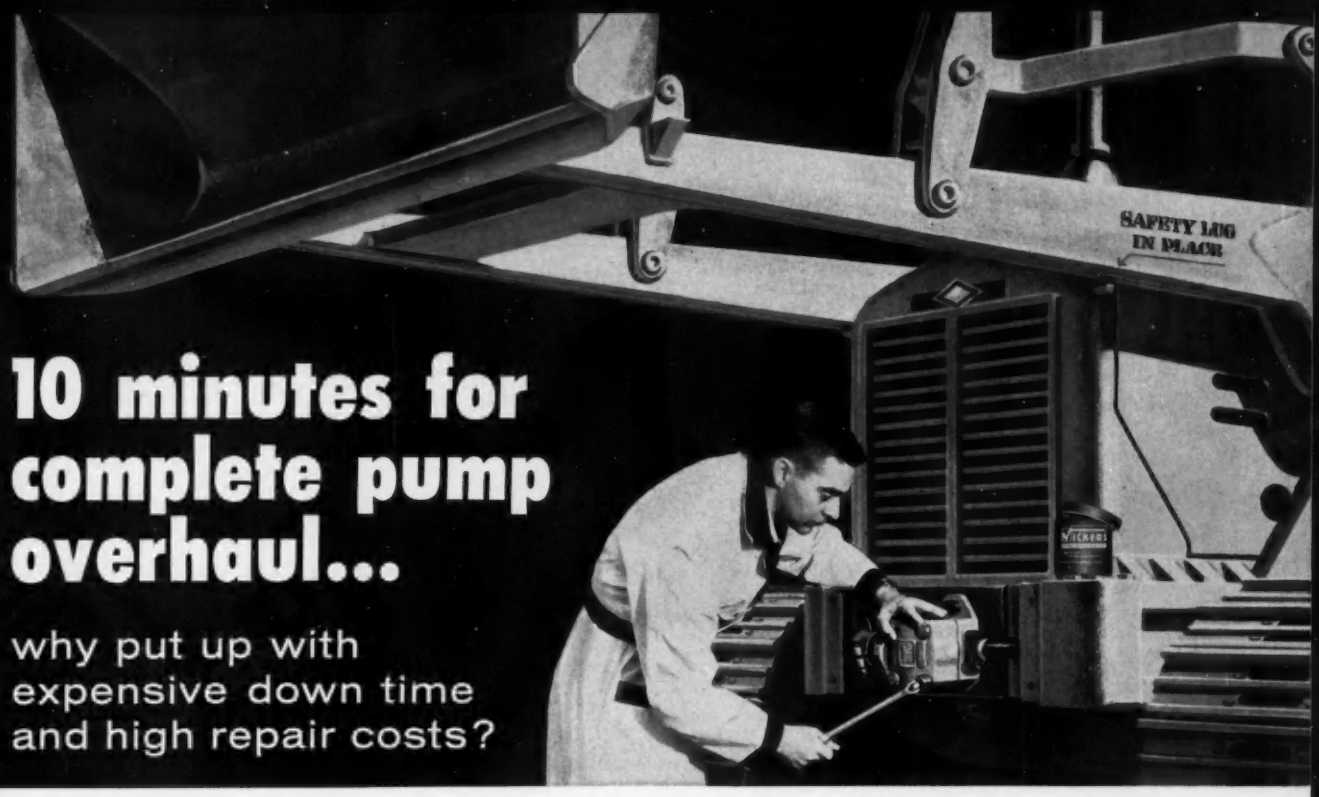


Diagram of pressure carrier.

FOR A GOOD START: BULLETIN 20.

This informative booklet gives a good picture of silver brazing and its benefits...includes details on alloys, heating methods, joint design and production techniques. Write for your copy.



10 minutes for complete pump overhaul...

why put up with expensive down time and high repair costs?

on the spot
maintenance with

VICKERS®

"High Performance" Pumps*
keeps your jobs on schedule

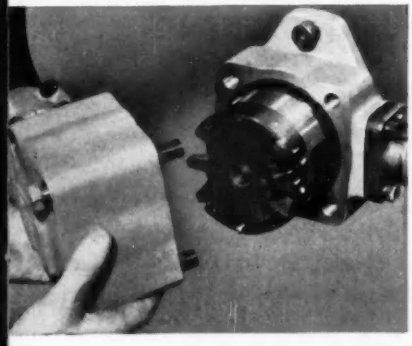
*PATS. & PATS. PENDING

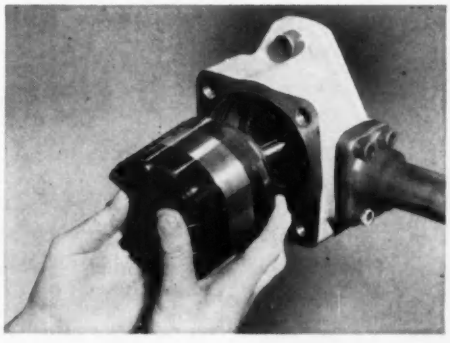
Without removing the pump from the vehicle, and without disconnecting hydraulic lines, the new Vickers "High Performance" pump can be completely overhauled by simply inserting a new pumping cartridge. The pumping cartridge contains all wearing parts in one replaceable unit and results in new pump performance. Write for Bulletin No. M5108 for performance characteristics.

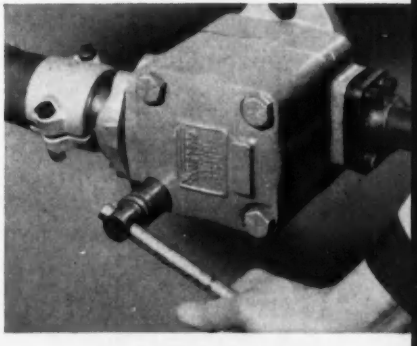
1. After safety, cleanliness and draining instructions have been followed per vehicle manufacturer's recommendations, take out four cover bolts and remove cover.

2. Take out old pump cartridge and insert new one. The cartridge includes cam ring, rotor, vanes, etc. —all parts in one assembly.

3. Replace cover and you have the equivalent of a new pump ready for long, trouble-free service.







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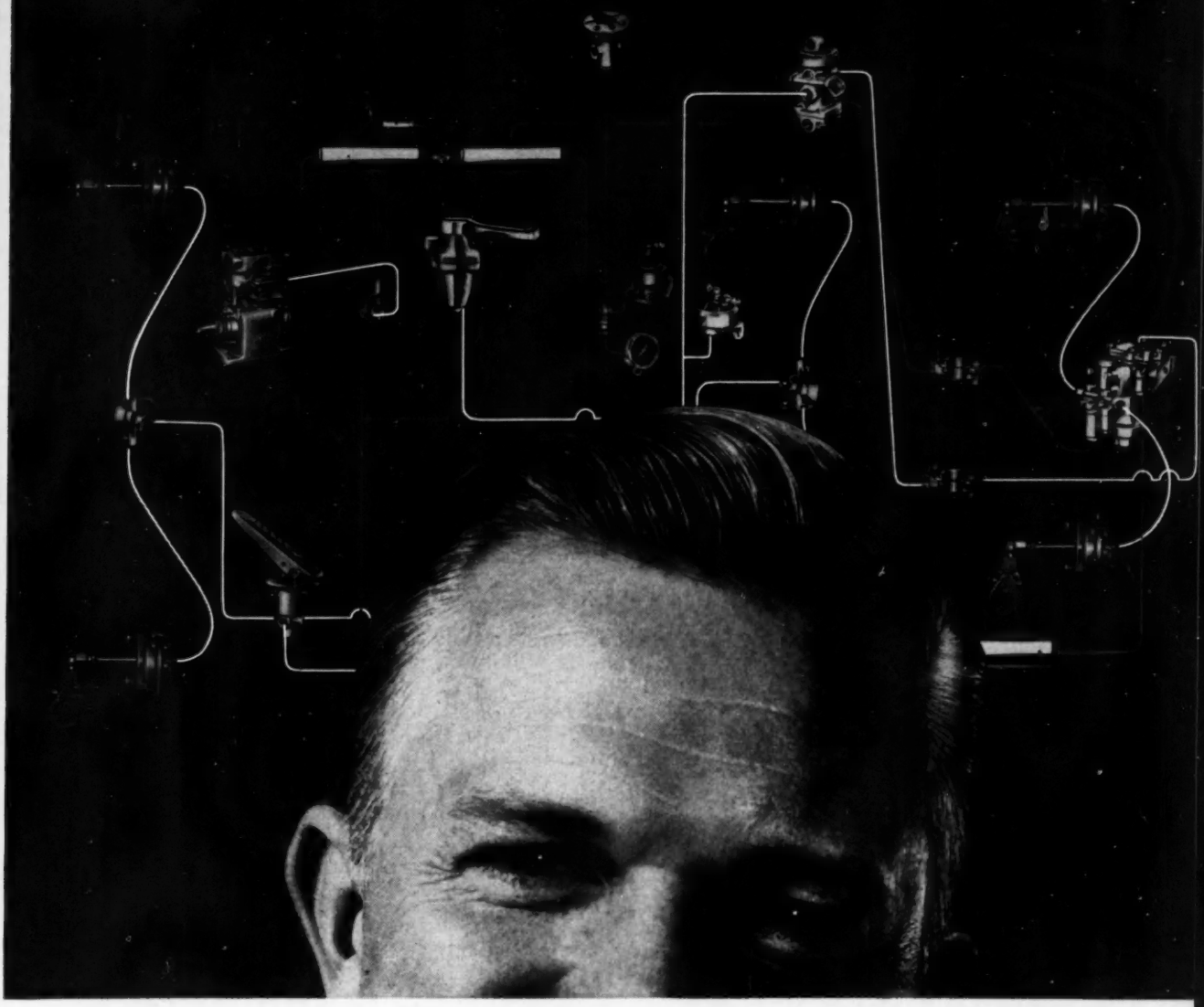
AIR BRAKE PARTS . . . . .

Which method

The parts buyer with the furrowed brow has reason to be worried. Better than anyone he knows that an automotive air brake system is no stronger than its weakest link, that failure of a single device can cause unnecessary downtime expense and may even risk lives and valuable property. A trivial saving, he well knows, can become a costly extravagance!

By way of contrast, the buyer at right reflects "systems serenity". He is systems conscious, and when he buys air brakes he buys genuine Bendix-Westinghouse Air Brake systems. He knows that Bendix-Westinghouse Air Brake equipment is "system engineered"—that each unit is designed to perform a specific operation in a closely related

BENDIX-WESTINGHOUSE AIR BRAKE SYSTEM



.... AIR BRAKE SYSTEMS

offers you more?

system to assure maximum performance of the entire train of devices—and not merely individual component performance.

A pioneer in development of automotive air brake systems, Bendix-Westinghouse has paced the industry for more than thirty years, helped to establish the high safety standards the American trucking industry presently enjoys. It is a position of responsibility that we accept and of which we are proud. That is why we shall continue to urge our customers, the truck manufacturers and fleet operators of America, to equip their trucks with complete Bendix-Westinghouse Air Brake systems—systems for whose performance, dependability, and long life we can accept full and complete responsibility.

Bendix-Westinghouse

AUTOMOTIVE AIR BRAKE COMPANY

General offices and factory—Elyria, Ohio. Branches—Berkeley, Calif. and Oklahoma City, Okla.

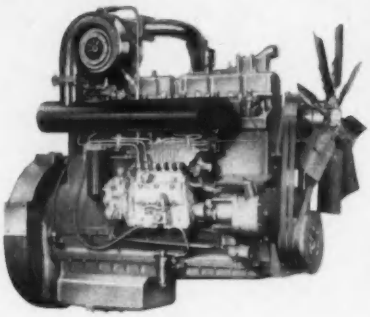
WAUKESHA
transport ENGINES

OVER THE ROAD OR OFF THE HIGHWAY

the BEST in all three!

DIESEL

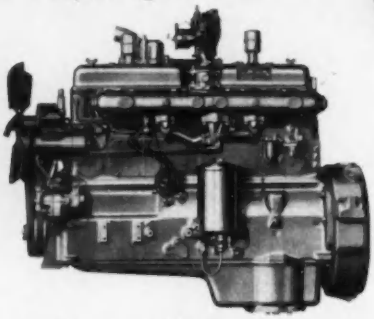
. . . in and out . . . down and up . . . over and through . . . go the trucks with Waukeshas—putting out the power that pulls and pays.



Normal or Turbocharged DIESELS from 60 to 350 hp.
Model shown is 148-DKBS—280 max. hp. 5¼ x 6 bore and stroke—779 cu. in. displacement.

GASOLINE

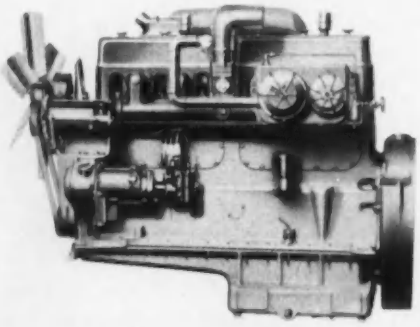
. . . where the pay-off is on payload — you'll make more miles and cut costs too, with these modern feature-packed transport engines.



High Torque GASOLINE Engines from 30 to 280 hp.
Model shown is 140-GZ—170 max. hp. 4⅝ x 5½ bore and stroke—554 cu. in. displacement.

LP-GAS

. . . those tremendous, crushing 30-ton, 35-ton, 40-ton loads . . . up stiff grades, without faltering or breakdown . . . day after day — with Waukesha.



BUTANE-PROPANE Engines from 40 to 300 max. hp.
Model shown is WAKB—300 max. hp. 6¼ x 6½ bore and stroke—1197 cu. in. displacement.

Send for Engine Bulletins

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Factories: Waukesha, Wisconsin and Clinton, Iowa

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THE OIL-RESISTANT, OZONE-RESISTANT NITRILE RUBBER

Now–the finest wire jackets can be Colored!

FOR SALES APPEAL • FOR SERVICE EASE

New Paracril OZO—a superior rubber compound developed by Naugatuck—makes possible *new eye appeal, new ease of identification*. And it outperforms standard wire jacket compounds many other ways, too!

Compare new PARACRIL OZO with other wire jacket rubbers. Prove for yourself, new PARACRIL OZO gives:

- significantly superior ozone resistance
- greater fuel and oil resistance
- much greater abrasion resistance than standard jacket compounds
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- *permanent retention of bright colors!*

If you are not already using PARACRIL® for your wire jacket compounds or similar products requiring such properties, chances are 1000 to 1 it's because you haven't yet *tried* PARACRIL OZO.

Why *not* try it—soon. Contact your nearest Naugatuck representative at the address below.

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where heavyweights roll on schedule!

Firestone **Perma-Tite** *Rims*

New Firestone Earthmover Rims are stress-tested and 100% fusion-welded for maximum strength!

Firestone's new Perma-Tite rims are the strongest you've ever used! Fusion-welding from both sides gives equal weld penetration throughout the section for maximum rim dependability. The exclusive Perma-Tite air seal is absolutely airtight, insures permanent protection to mounted tires. Firestone Steel Products Company's stress testing results in rim reinforcement at high strain points. Perma-Tite earthmover rims are the truest rolling you can own—they deliver full tire support, reduce sidewall flexing and let tires run cooler for longer service. Specify Firestone Perma-Tite rims as original equipment and replacements. They're available for tubeless or tubed off-the-highway tires.

SPECIAL PROTECTION against rust and corrosion for longer rim life, better tire performance.

INTERCHANGEABLE in complete units or by components with all Earthmover rims and parts.

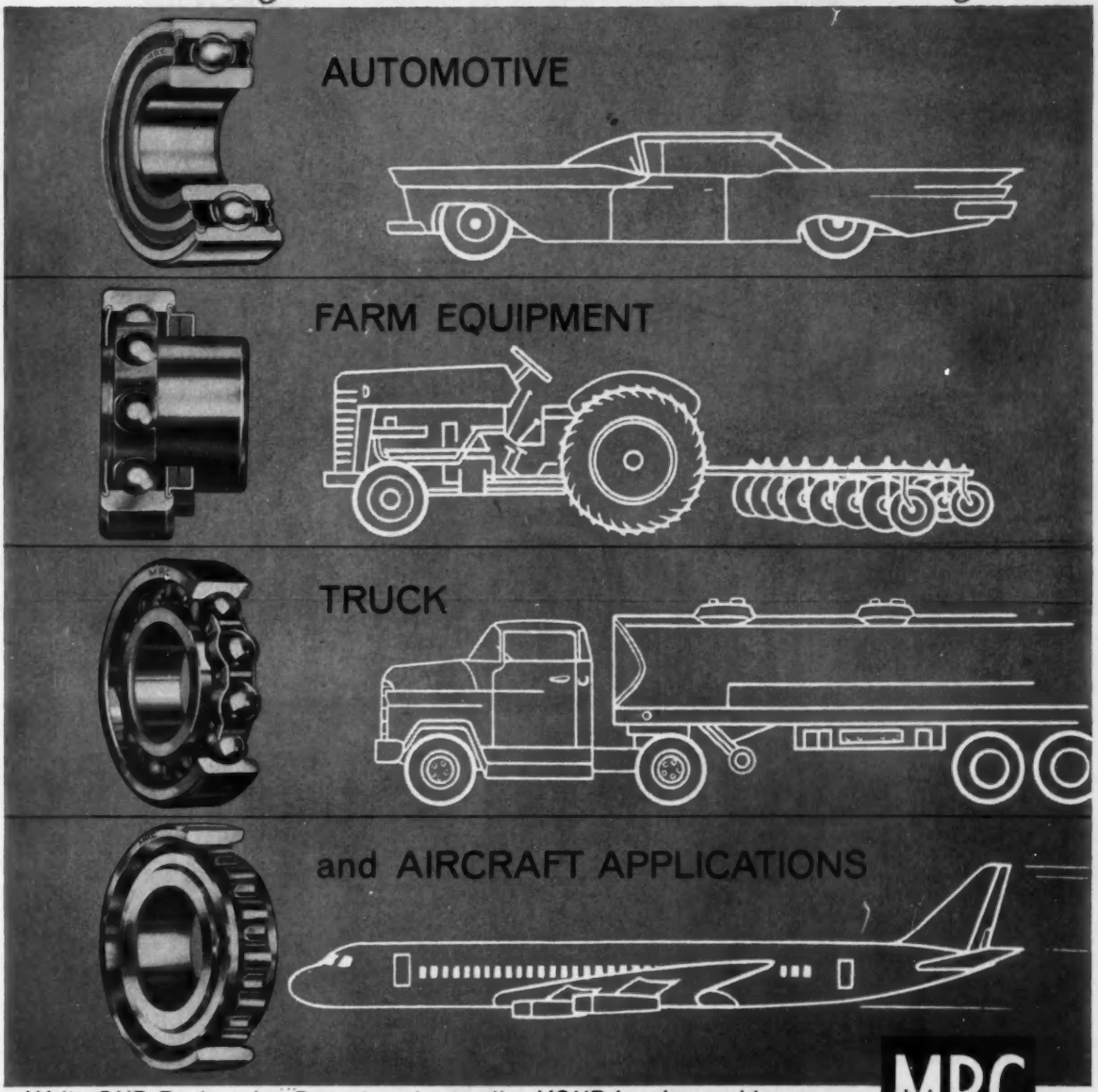
COMPLETE AIR SEAL insures retention of air at recommended pressures, delivers longer tire service.

FIRESTONE STEEL PRODUCTS CO. *Akron 1, Ohio*

INTEGRITY, ACCURACY, QUALITY, DEPENDABILITY

MRC 61 YEARS OF EXPERIENCE

in design and manufacture of bearings for



Write OUR Engineering Department regarding YOUR bearing problems

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NEW, IMPROVED MODEL SPEEDS BRAKING TIME

Here's a Treadle Type Foot Control Valve you can't beat for application and release time. Redesigned from beginning to end, it's compact, light, easily adapted to varying installation requirements . . . Trim, modern styling adds a lot to its appearance—and the tread is rubber-capped for extra safety's sake . . . We'll be glad to give you a demonstration, or furnish a sample for your examination.

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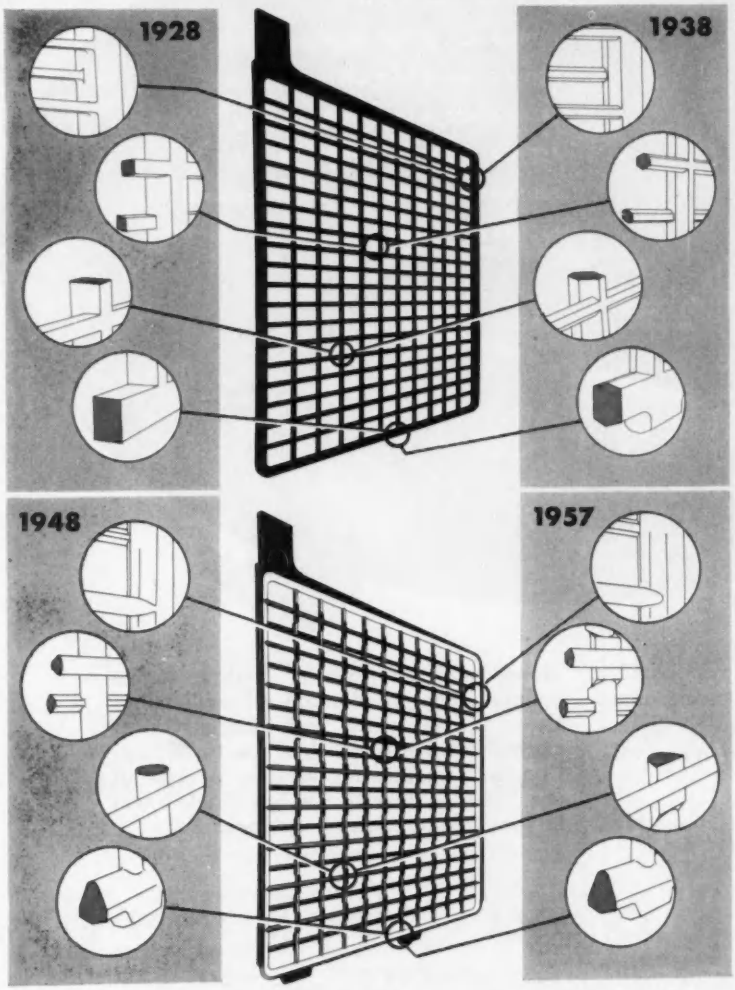
ONE OF THE 400 LARGEST AMERICAN CORPORATIONS

to GLOBE RESEARCH no battery is ever perfect

from Globe Research

Significant design changes in grid cross sections 1928 through 1957



. . . grids that are designed for:

- **High strength**
- **Corrosion resistance**
- **Good conductivity**
- **Greater oxide retention**

Charts at the left illustrate progressive changes in grid design resulting from Globe's 30-year advance toward battery perfection through research and development. These changes are small physically, but very significant in bringing buyers the efficient, low-cost, peak-performance battery of today . . . the Globe Spinning Power Battery . . . unsurpassed in quality for either original equipment or replacement.

For more information on grid design write for Bulletin G57.

Globe Spinning Power Batteries are now available for fast, low-cost shipment from 16 strategically located plants — 15 (*) now producing dry-charged batteries:

*ATLANTA, GA., *DALLAS, TEXAS, *EMPORIA, KANSAS, *HOUSTON, TEXAS, *LOUISVILLE, KY., *MEDFORD, MASS., *MEMPHIS, TENN., *MILWAUKEE, WIS., *MINERAL RIDGE, OHIO, *PHILADELPHIA, PA., *REIDSVILLE, NO. CAROLINA, *SAN JOSE, CALIF., *HASTINGS-ON-HUDSON, NEW YORK, *LOS ANGELES, CALIF., OREGON CITY, OREGON, *TAMPA, FLORIDA.

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This group of sleeve bearing alloys permits the engineer to design for all conventional commercial applications. At the same time, he can meet his performance and cost requirements.

Each of these alloys has been thoroughly proved and accepted by leading engine builders. Our production of millions of sleeve bearings each year assures you of the highest quality, efficiency and economy. Complete engineering service. A copy of the "Sleeve Bearing Design Guide" will be sent free on request. Address:

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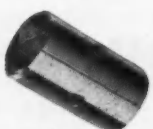
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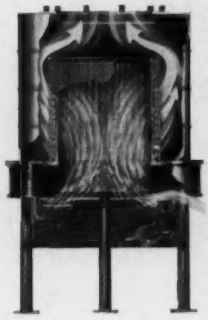

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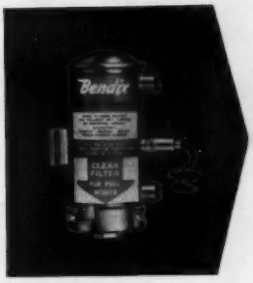

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Rated hp	375 @ 2100 rpm
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Height	56½
Width	39½"
Flywheel housing SAE	No. 1

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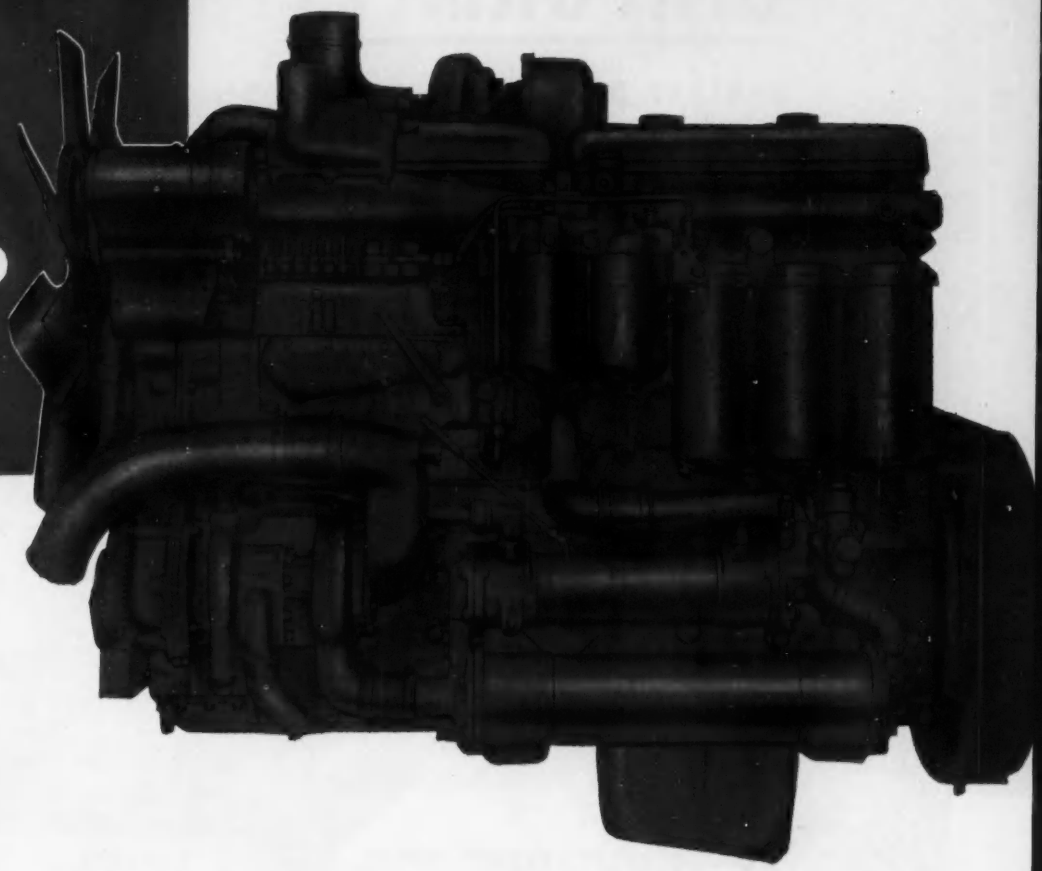

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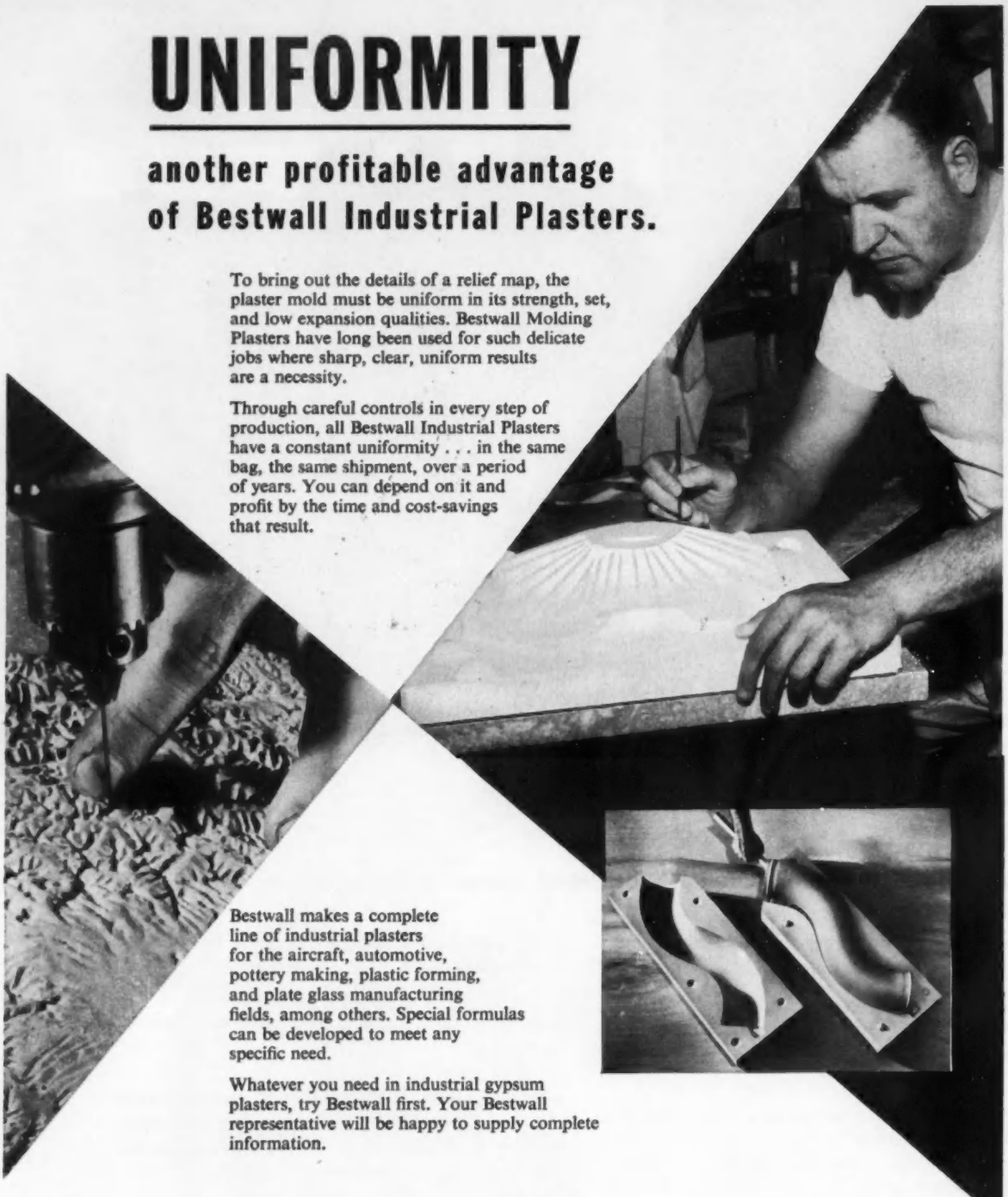

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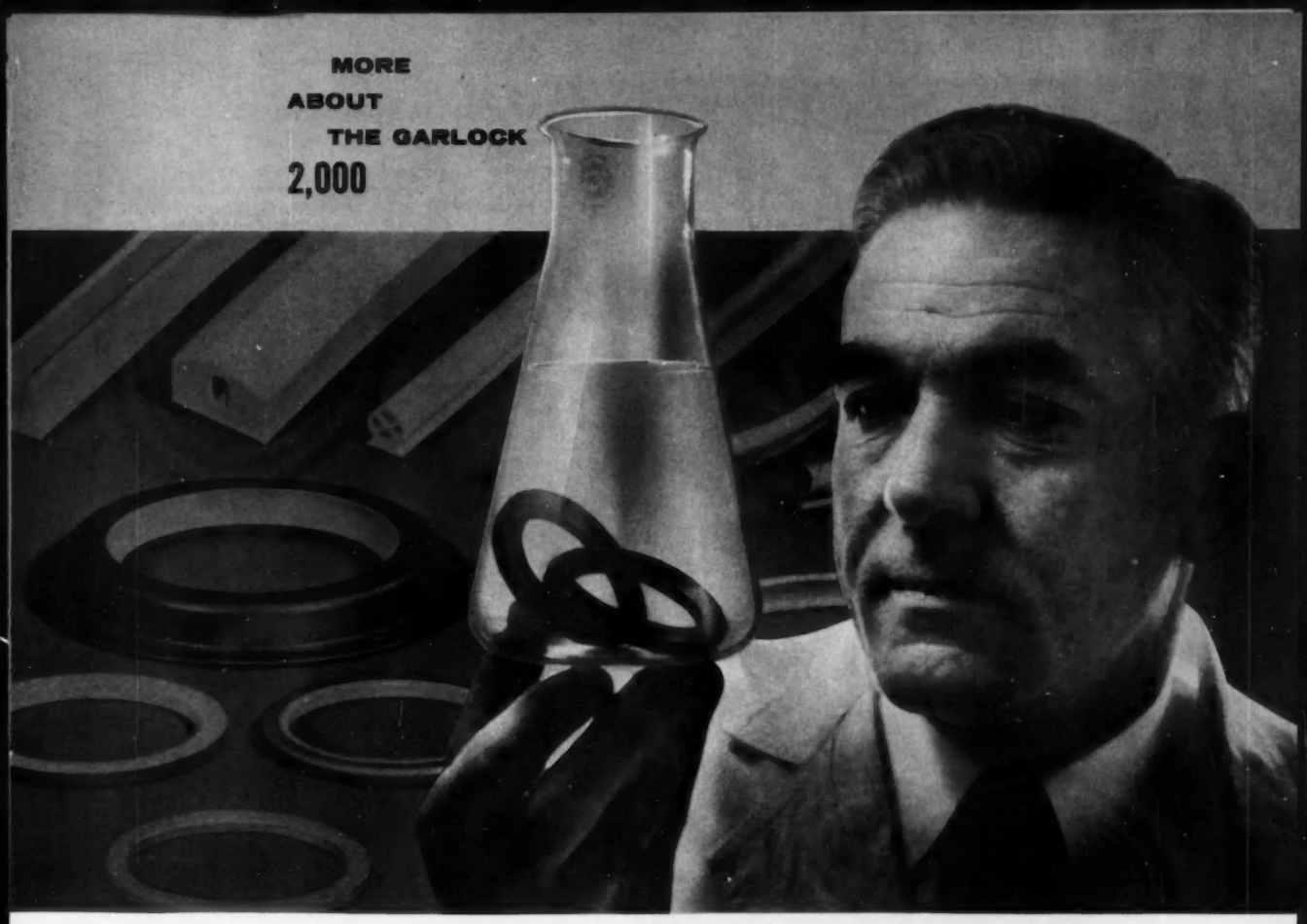

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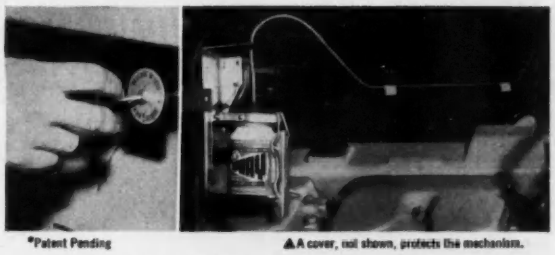

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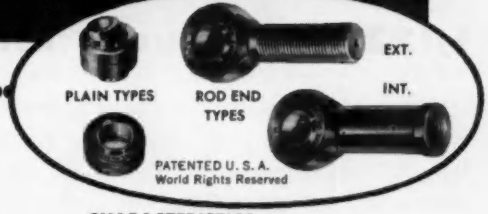

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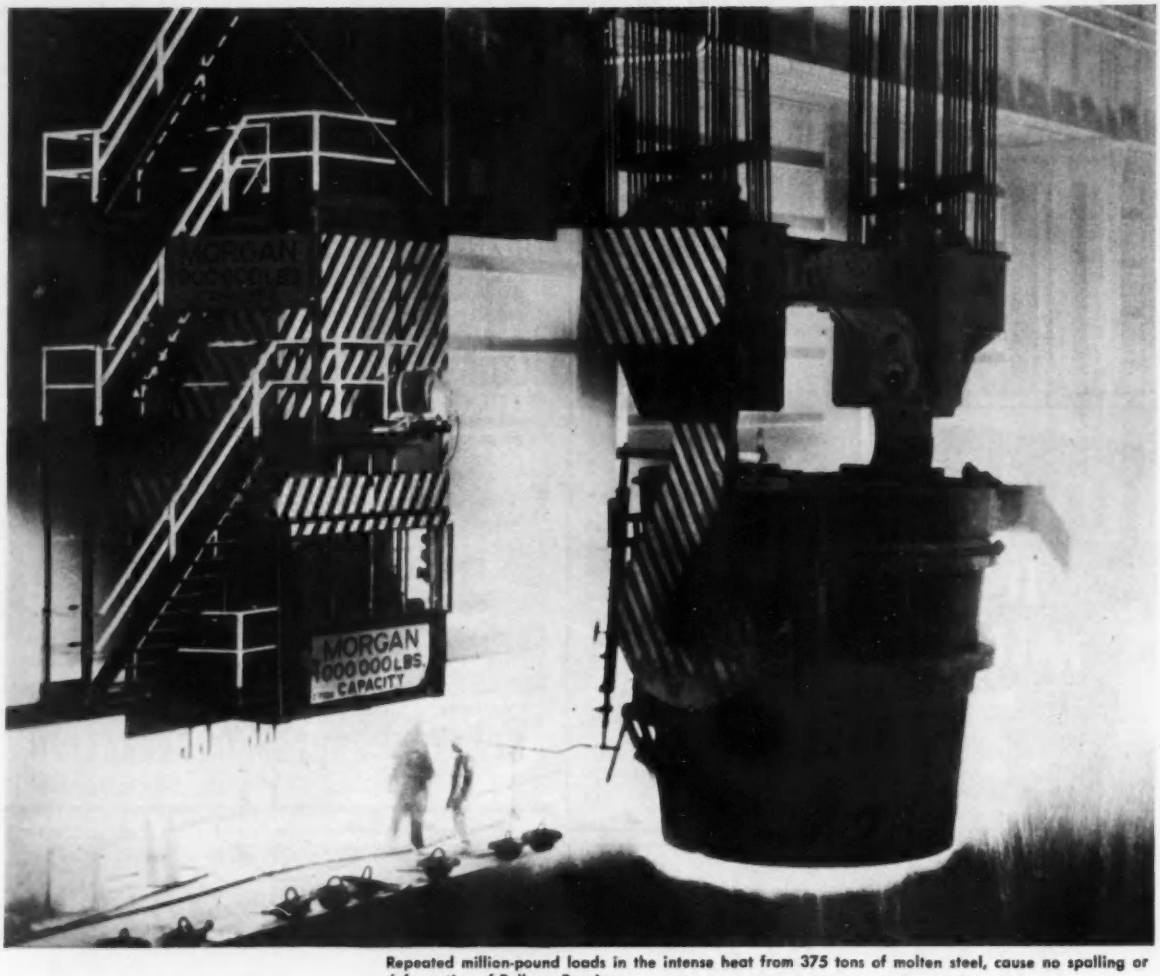

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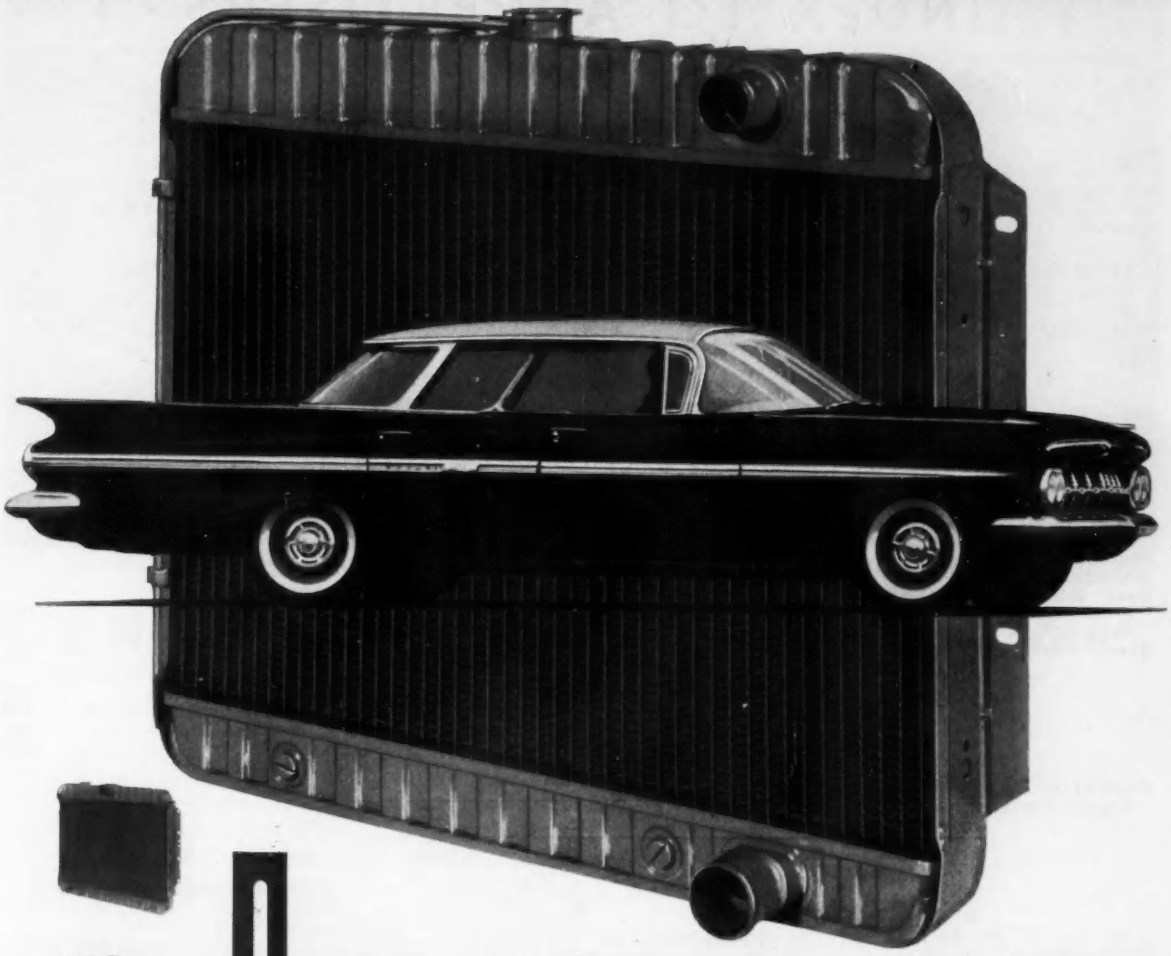

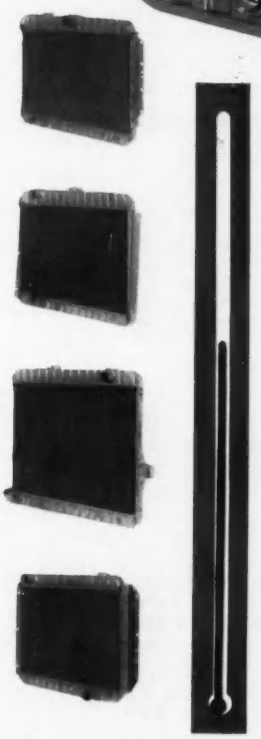

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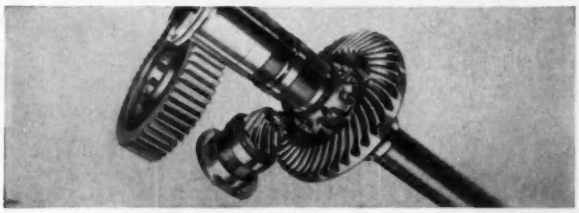

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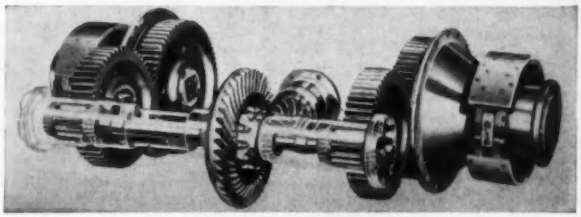

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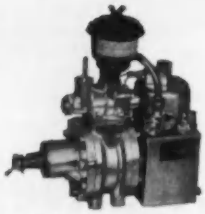

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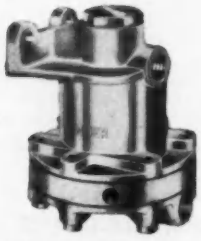

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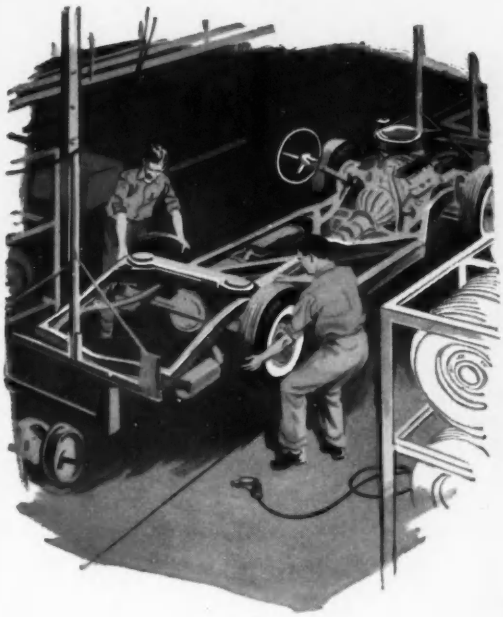
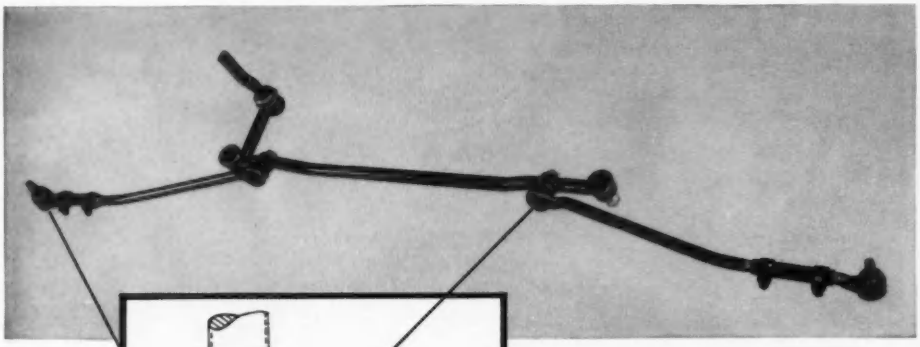


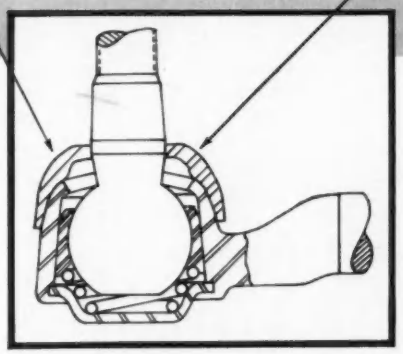
New product from Thompson

GREASED-FOR-LIFE STEERING LINKAGE . . .

New developments in chassis and front end parts have been coming from Thompson's Michigan Division for many, many years. Almost every make of passenger car, truck, farm tractor or off-the-road vehicle performs better because of Thompson contributions. Shown here is another Thompson development ready now for manufacturers to use in models to come.



Completely assembled, GREASED-FOR-LIFE steering linkage for future passenger car application.



1—Provides constant take-up for wear.
2—Permanently lubricated.
3—Has excellent insulation qualities to reduce road noise transmission from running gear.
4—Exceptionally long life.

For help in developing and manufacturing front end and chassis parts for your models of the future, call on Thompson's Michigan Division. We have the skills and facilities to help you build a better vehicle usually at a lower cost.

TRW

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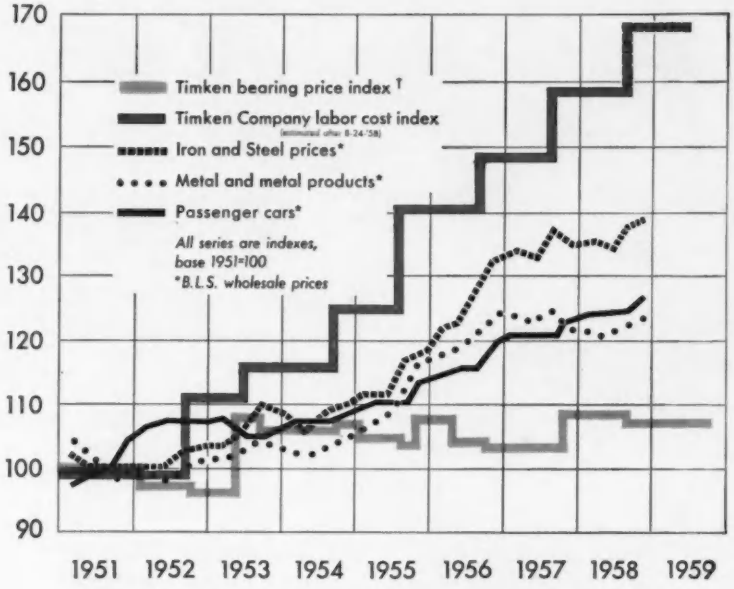
Fewer bearing sizes, lower bearing costs...

Good news for car makers! The red line on the chart at right shows how the cost of Timken® bearings for automobiles has stayed down low—while everything else has gone way up. You helped keep the cost down by standardizing on new-design Timken tapered roller bearings. The bearings made by revolutionary cost-cutting methods in our ultra-modern Bucyrus, Ohio plant (see below).



† COMPUTED FROM TOTAL VEHICLE COST OF PINION, DIFFERENTIAL, REAR AND FRONT WHEEL BEARINGS.

That's beating inflation with standardization

More good news to come! By standardizing on still fewer bearing sizes (particularly in pinion and differential applications), auto makers can keep these machines going full tilt. By making the most of the new production techniques you will help lower production costs. Manufacturing savings can then be passed on to you. Standardize on still fewer bearing sizes and specify Timken—the bearings made by advanced mechanization—and save! The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ont. Cable: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*

TIMKEN® TAPERED ROLLER BEARINGS

First in bearing value for 60 years